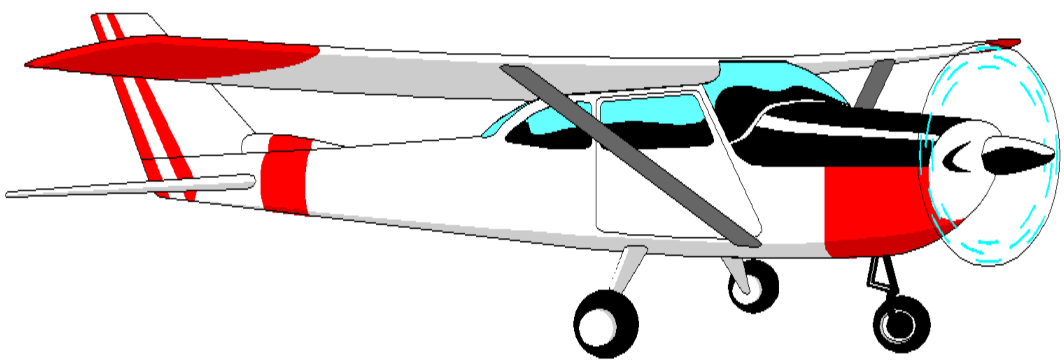
Civil Air Patrol
Southwest Region
Mission Observer Course



About This Document

Several Reserve Officers in the CAP/RAP program serving the Texas Wing and the Southwest Region of the Civil Air Patrol developed this material. While every effort has been made to ensure its accuracy, things change and it is quite possible that some material may be affected. Ultimately, you need to keep up with the CAP-USAF regulations to ensure your information is up to date. As changes occur, individual chapters of this document may be updated. Compare the following table to the latest revision information to determine whether this document contains the latest information.

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	Introduction and Table of Contents	2.2	15 May 99
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This course sets forth the academic preparation required for the pursuit of the CAP Mission Observer rating as set forth in CAPR 50-15, Training for CAP Operational Missions. It is assumed that you are already qualified as a Mission Scanner. The scanner's primary responsibility is to maintain constant visual contact with the ground while over the search area. This responsibility makes each scanner a key member of the search aircrew, and he or she usually sits behind the pilot in the aircraft.

The observer, on the other hand, has expanded duties to assist the pilot and usually sits in the right front seat. In addition to a primary duty of scanning, the observer helps with planning, navigation, communication, and documentation. The scanner and observer may also hold a pilot rating, but their assigned duties on a particular mission will dictate their responsibility.

The material selected for the manual is directed by CAPR 5-15, Attachment I, Mission Observer Training Guide.

Three (3) CAP regulations will direct your upgrade and operations as an observer: CAPR 50-15, Training for CAP Operational Missions; CAPR 55-1, CAP Emergency Services Mission Procedures; and CAPR 60-1, CAP Flight Management. Your knowledge of their contents is essential.

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Chapter

1

1. Observer Duties and CAP Missions

1.1 Observer duties

The mission observer has a key role in the CAP missions described later in this chapter, and the duties associated with that role are demanding and numerous. They may include planning, aircraft navigation, radio communication, crew management, weather interpretation, and scanning. It is also very desirable to have another crewmember who is familiar with the various phases of the overall operation, because that increases the overall safety and effectiveness of the mission. This manual will focus primarily on the SAR mission because that is the most common one you will fly. However, much of the information presented here applies to all CAP missions. Regardless of the type of mission flown, a proficient mission observer can reduce pilot workload and contribute substantially to a safe, efficient mission.

All air search missions are conducted under the supervision of the aircraft commander (mission pilot). Responsibilities of an observer in an assigned aircraft on CAP operational missions include:

- Maintaining a chronological flight log of all observations of note, including precise locations and sketches.
- Reporting observations upon completion of each assignment. **You are the eyes and ears of the incident commander.**
- Employing effective scanning techniques.

The following list is taken from CAPR 55-1 and expands on the responsibilities of observers assigned to a typical air search mission:

- Wear appropriate dress for the mission (e.g., gloves, sunglasses, and uniform appropriate for climate and terrain).
- Use equipment needed for the mission (e.g., binoculars, camera, clipboard, sunglasses, survival equipment, or overnight kit).
- Ensure all credentials are current and carried during the mission (i.e., CAP membership card, CAPF 101, and CAPF 76).
- Complete mission kit (e.g., gridded charts, CAPR 55-1, plotter, flight computer, and local maps).
- Complete sign-in and report to Air Operations upon arrival at the mission base.
- Obtain crew assignment.
- Report with Mission Pilot for briefing.

- Assist Mission Pilot in planning the mission. Ensure that responsibilities while in transit and while in the search area are clearly defined. The pilot and observer must agree as to when the observer will handle the radios and/or operate navigational aids (especially the GPS).
- Divide and assign scanning responsibilities.
- Coordinate with the scanner to maintain an accurate flight log of all observations on your sortie. Record all sightings to include the time and geographical location. Include such things as other aircraft, ground parties, descriptive information concerning your search area, weather conditions such as sun position and cloud cover, old wreckage or items that can be mistaken for wreckage, and all possible sightings.
- Conduct the mission as briefed and planned.
- Advise mission base of any problems or delays using procedures obtained in briefing. Return to mission base on time.
- Report with the Mission Pilot for debriefing immediately upon return to mission base. Applicable portions on the reverse of CAPF 104 should be completed when reporting for debriefing.
- Report availability for additional assignments.
- Upon completion of the day's mission assignments, return borrowed or assigned equipment.

Once team members have been briefed on the mission and accomplished the necessary planning, observers determine that all necessary equipment is aboard the airplane. Checklists help ensure that all essential equipment is included, and vary according to geographic location, climate, and terrain of the search area. Items on the observer's checklist should include CAP membership and specialty qualification cards, current charts and/or maps of the search area, flashlights, notebook and pencils, binoculars, strobe light, mirrors, flares, compass, and survival kit. Prohibited items, such as firearms, should also be listed to ensure none are included. Imaging equipment (e.g., camera or camcorder) may be included to assist in communicating the location and condition of the search objective or survivors. Unnecessary items or personal belongings should be left behind. The mission observer also assists the pilot in ensuring that all equipment aboard the search aircraft is properly stowed. An unsecured item can injure the crew or damage the aircraft in turbulence. The observer must also ensure that the aircraft’s windshield and windows are clean.

Checklists should address anticipated personal needs of the observer and scanners, including instructions to dress appropriately for the climatic conditions explained in the briefing. For instance, one search team preparing for a mission in the Alaskan wilderness and other preparing for a mission in the Florida Everglades would carry very different survival equipment and personal clothing. The mission observer helps ensure the survivability of the crew by anticipating requirements in the unlikely event crewmembers are confronted with an unexpected survival situation.

Mission observers are vital to search and rescue operations. While their primary responsibility when in the search area is visual search (i.e., scanning), they perform other important duties as well. While transiting to and from the search area, observers assist the pilot by handling communications and providing navigational assistance. While in the search area, the observer periodically verifies aircraft position and may assist the pilot in operating or interpreting navigational aids (navaids).

Handling radio communications and providing navigational assistance while in transit allows the pilot to devote more time to flying the aircraft and preparing for the search. This preparation enhances the pilot's ability to fly the search pattern safely and precisely. Maintaining situational awareness (i.e., location of the aircraft) also reduces pilot workload.

Another observer duty is to supervise the scanner(s) to ensure scanning efforts are coordinated and effective. The observer divides and assigns scanning responsibilities during the mission briefing, and ensures that the scanner(s) performs their assigned duty. Monitoring the duration of scanning activity and ensuring adequate crew rest helps combat fatigue and maximizes effective search coverage.

The observer should be acutely aware of the fact that fatigue reduces search effectiveness. Fatigue can be reduced by changing scanning positions at intervals of 30 minutes to one hour (if the size of the aircraft permits), periodically rotating scanners from one side of the aircraft to the other, permitting scheduled on/off periods (if enough scanners are aboard and flying time permits), permitting a reasonable amount of communication between crewmembers, and, at night, keeping lights inside the aircraft dim to reduce reflections and contrast.

Coordination helps ensure that you do not miss something outside the aircraft while you are busy inside the aircraft. For example, you're in the search area and you need to verify a location on the sectional map. You must ensure that the crew knows that you will cease scanning for the time it takes to verify position. If there is only one scanner aboard, you should direct the scanner to look out the right side of the aircraft and ask the pilot to cover the left side as best she can (if possible, wait until the pilot workload is lowest to do this).

Managing communications activities aboard the search aircraft is another vital mission role. The observer must be aware that excessive talking between crewmembers or with ground personnel can easily evolve into a gabfest. This not only degrades mission effectiveness, it can cause the pilot to miss a vital transmission from air traffic control. The observer's self-discipline helps set the tone for the cockpit work environment.

By assuming these additional responsibilities the observer makes it possible for the crew to perform their duties with a greater degree of safety and effectiveness.

1.2 Observer Log

The observer must become proficient in keeping an in-flight navigational log. The log should be maintained from take-off until landing. Since this skill requires training and experience, observers are encouraged to maintain a navigation log on every flight they take. Also, use the GPS whenever possible. Ask for sample problems using your local sectional chart; this will help you become proficient and confident.

The observer's log contains all information pertinent to the sortie, and events and sightings are recorded when they occur. It is very important to accurately determine and log the geographical location of each sighting at the time of the sighting (including latitude and longitude). During debriefing, information from this log is used to complete the CAP Form 104 (a permanent mission record). This form is passed up to air operations and the incident commander. Combined with other search data, they use this information to help determine overall search coverage and effectiveness and to make plans for future sorties.

1.3 CAP missions

As a review, the Civil Air Patrol (CAP) has three equally important missions—Aerospace Education, the Cadet Program, and Emergency Services. The Observer Course involves all aspects of the Emergency Services mission, including civil defense, disaster relief, search and rescue (SAR), life support, and emergency communications.

As the civilian noncombatant auxiliary of the United States Air Force (USAF) and a private nonprofit corporation, the CAP was established under Federal law by Congress (36 U.S.C. 201-208 1101). The CAP is tasked with a wartime mission, peacetime disaster relief mission, a SAR mission, counter narcotics (CN), support of the American Red Cross, and U.S. Customs support. A Memorandum of Understanding (MOU) between the USAF and CAP was instituted on 25 Jan 91 that defines the current duties and responsibilities of the CAP. CAPR 55-1 contains detailed information concerning CAP operations, and CAPR 50-15 provides specific guidance for CAP training. No supplements or operating instructions (OI) may be issued to these regulations below Wing level and only then with prior written approval by Nations Headquarters/DO.

1.3.1 The Wartime Mission

Information concerning the CAP wartime mission is contained in CAPR 55-1, Chapter 6. CAP OPLAN 1000 provides for CAP support to the National Command Authorities (NCA) in a declared national emergency operation—in other words, war. The CAP would supplement the military defense with a civil defense for the protection of life and property in the even of an attack on the U.S. Specifically, the CAP would:

- provide a communications network (fixed, mobile, and airborne)
- provide assessment of damage to highways and facilities
- support State and Regional Disaster Airlift (SARDA)
- provide radiological monitoring and decontamination teams

Command and control during these operations remains within the CAP chain of command at all times. Although operational control of a particular mission may rest with another agency, CAP directives apply to CAP resources.

A national emergency may also invoke the Security Control of Air Traffic and Air Navigation Aids (SCATANA) plan. The purpose of this plan is to provide security control of civil and military air traffic, navigational aids, and airspace use. It may involve the use of military interceptors, directed dispersal, landing, or grounding of aircraft, shutdown of navigational aids, or IFR-only operations.

Mission records are to be kept for 4 years and reimbursement for fuel, oil, and maintenance is IAW CAPR 173-3.

1.3.2 Peacetime Disaster Relief

Information concerning the CAP peacetime disaster relief mission is contained in CAPR 55-1, Chapter 5. During a peacetime disaster, CAP resources are tasked for assistance as a component of the Federal Emergency Management Agency (FEMA) Urban Search and Rescue Program, or under USAF auspices for military assistance to civil authorities. These operations could involve assistance during flood, forest fires, toxic spills, earthquakes, storms, etc. It does not include unlawful civilian violence or enemy attack.

Command and control of CAP resources remains with the CAP. If the CAP is the lead agency, the CAP incident commander may be assigned as the overall incident commander. Most likely, however, is that overall control will rest with an outside agency and CAP will integrate its resources within the Incident Command System (while still maintaining control of CAP resources).

CAP assistance to law enforcement agencies is restricted to patrol, reconnaissance, and reporting only. CAP members may not be deputized, actively arrest or detain individuals, nor do they have any authority to restrict persons by means of force, actual or implicit. The senior CAP member on duty will ensure these restrictions are understood by both the CAP member and law enforcement agencies.

A Natural Disaster Employment Report is called a Tempest Rapid (I or III). The designated incident commander sends the report to the CAP-USAF liaison officer. Mission records are kept for 4 years. Reimbursement for fuel, oil, maintenance, and communications is IAW CAPR 173-3.

1.3.3 Search and Rescue (SAR)

Information concerning the CAP search and rescue mission is contained in CAPR 55-1, Chapter 4. The USAF is the SAR coordinator for the Inland Region of the continental United States (CONUS). The Coast Guard controls the Maritime Region and the Overseas Unified Command controls the Overseas Region.

Within the CONUS, the Air Force Rescue Coordination Center (AFRCC) of the USAF carries out the National Search and Rescue Plan. As an auxiliary of the USAF, CAP provides the primary resources (4 out of 5 searches) for SAR. Chapter 4 of CAPR 55-1 sets out specific guidance for air and ground operations, including activation procedures, command and control, mission management, air and ground operations, and mission suspension or closure.

Record requirements are listed with a four-year holding period, and reimbursement is IAW CAPR 173-3.

1.3.4 Customs

The CAP provides reconnaissance of the continental U.S. borders IAW a letter of agreement with the U.S. Customs Agency. Mission emphasis tends to reflect the changing political climate. Reimbursement is IAW CAPR 173-3.

1.3.5 Counter-narcotics operations (CN)

Information concerning the CAP counter-narcotics mission is contained in CAPR 55-1, Chapter 7. The CAP, with the concurrence of the USAF, has established national agreements with the U.S. Customs Service’s Drug Enforcement Administration and the U.S. Forest Service to participate in a program of air reconnaissance to assist in locating illicit drug traffic and growing activities. The CAP role is limited to data gathering and supporting base communications. Actual CAP emergency services missions have priority over CN operations for the use of CAP resources.

No CAP region, wing, or other unit may supplement, amend, restrict or change these agreement guidelines or procedures. CAP members may not participate in arrest, seizure, or detention operations. Command and control remains within the CAP chain of command. Mission execution is IAW CAPR 60-1 and CAPR 55-1. Missions are debriefed to the CAP CN officer. Reports are required and reimbursement for fuel, oil, maintenance and communications are IAW CAPR 173-3. Travel and per diem may also be authorized.

1.3.6 American Red Cross support

Information concerning the CAP American Red Cross support mission is contained in CAPR 55-1, Chapter 9. The CAP has agreed to provide ground and air transportation, communication, and manpower to assist the Red Cross in relief operations. Specifically, the CAP may transport blood, blood products, organs, and tissue. A transport mission pilot qualification is required. Red Cross personnel may be carried on CAP aircraft for tissue retrieval with the proper prior approval. Command and control remains within the CAP. Reimbursement is from the Red Cross IAW CAPR 173-3. The mission pilot and CAP unit CC file reports.

1.3.7 Other partner agencies

CAP has Memoranda of Understanding (MOUs) with other national agencies such as the U.S. Forest Service, FEMA, the Salvation Army, Department of the Interior, Federal Aviation Administration, Federal Highway Administration, NASA, National Communication Systems, National Weather Service, National Transportation Safety Board, and the U.S. Coast Guard Auxiliary. Wings may have MOUs with state agencies such as the Department/Division of Emergency Management, Department of Public Services, State Forest Service, and State Park Service.

Air Force assigned mission status may be extended to national, state, and local MOU missions. The basic USAF/CAP MOU provides that Air Force non-reimbursed assigned mission status will apply to “support missions requested by a state/local government or private agencies which are specified in memoranda of understanding or letters of agreement that have been signed and approved by appropriate Air Force authority.”

Air Force mission numbers will not be issued for CAP missions in support of other federal, state, local or private agencies unless there is a MOU or letter of agreement with that agency or organization. Each MOU addresses the issues of third party liability coverage, Workmen’s Compensation benefits, and expense reimbursement, and specifies if the Air Force or the supported agency/activity will provide the coverage.

All of the MOUs make it clear that support is given on an “as available” basis, and that U.S. Air Force missions have top priority.

1.4 Liability

Since 1992, state and local missions no longer give Federal Employee Compensation Act (FECA) coverage to CAP members. These missions are now designated as CAP “corporate missions” IAW CAPR 60-1 and are covered by commercial insurance. Therefore, sponsoring agencies need to extend state Worker’s Compensation and liability protection to both CAP members and the corporation whenever possible.

FECA coverage is provided for all “Air Force assigned missions” as defined in CAPR 60-1 and the USAF/CAP MOU. Generally, non-CAP members may not ride aboard CAP aircraft. Exceptions are outlined in CAPR 60-1. CAP members are covered by the Good Samaritan law and should only attempt the most basic first aid procedures unless specifically trained.

1.5 Operational Agreements

To facilitate mission execution, prearranged agreements are already in place in anticipation of most contingencies. These exist at the national, regional and state/local levels so that we do not need to “re-invent the wheel” for each new tasking. These agreements are formalized through the respective agencies’ chains of command and signed off at all levels so that everyone understands their responsibilities and the actual level of involvement for each contingency.

1.6 Forms

OPLANs, MOUs, regulations and agreements do not get the work done—people do. To ensure standardized training and mission accomplishment, a series of forms facilitate the observer’s upgrade and mission execution. These forms are the CAPF 76 (ROA), CAPF 101T, CAPF 101, CAPF 104, FAA 7233 Flight Plan, and CAPF 108.

Possession of the CAPF 76 is a prerequisite to the Observer qualification. Requirements are set forth in CAPM 100-1, Communications. An understanding of the phonetic alphabet and message transmission/reception must be demonstrated to the unit communications officer.

CAPF 101T is the Advanced Specialty Qualification Training Card, issued by the unit commanding officer. The card allows the CAP member to receive training on operational missions under direct supervision of qualified instructors. You may train in three specialties concurrently. Completion of LVL 1 is a prerequisite to issuing a 101T card. Training areas listed on the 101T card do not expire, but once qualified in a training specialty, it is deleted from the 101T and transferred to the CAPF 101, Specialty Qualification Card.

Once qualified, you may be assigned to perform duties on CAP operational missions. The currency requirement for each specialty is at least one mission (actual, training, or proficiency sortie) every two years. In addition, CAPR 60-1 requires an academic biennial review of material for pilots, scanners, and observers. If you lose your currency, recurrency is obtained IAW CAPR 50-15. Qualification transfers are allowed between CAP wings.

CAPF 104 is the Flight Plan/Briefing/Debriefing Form. The pilot or observer usually makes entries on this form. The SAR mission usually begins with a general briefing by the incident commander, followed by individual sortie briefings. The front side of the CAPF 104 is used as a checklist to ensure that all areas of the mission are briefed.

The mission log that is kept by the observer during the flight provides the information needed to complete the reverse side of the CAPF 104 during debriefing.

A CAP Flight Plan (CAPF 104 or 84) is required for all CAP missions. Usually, an FAA Flight Plan is also required; this is prepared and filed by the mission pilot and must be closed at the end of the flight, usually with an FSS. Flight Plans show details, such as the intended route of flight, ATD and ETA, fuel, aircraft type and color, and the number of souls on board, which facilitate rescue efforts in case of an emergency.

CAPF 108 is used to claim reimbursement for CAP missions IAW CAPR 173-3. Generally, fuel, oil, limited maintenance, and mission-essential communications expenses are covered by the tasking agency. Suspense for filing is NLT 30 days after mission completion. Remember – keep those receipts!

1.7 Summary

You, as the observer, implement the CAP Emergency Services mission. Whether tasked during war or peace, a series of MOUs, plans, agreements, and regulations establish your authority and responsibilities, and guide your actions. CAP forms help document and manage mission accomplishment in an orderly manner. CAPR 50-15, 55-1, and 60-1 are your primary sources for written CAP operational guidance. Read your regulations and become an authority in your specialty.

1.1.1.1.1.1 Chapter

2

2. Aircraft Operations

2.1 Basic aircraft structure

An understanding of the basic elements that make up the structure of most general aviation aircraft will help you understand how the aircraft is controlled. When executing search patterns, the mission observer should know the aerodynamic parts that cause the aircraft to turn, climb, and roll.

The basic aircraft control surfaces can be seen in Figure 2-1, along with a general aircraft design. The effects of aileron, elevator, and rudder movements can be seen in Figures 2-2 through 2-4.

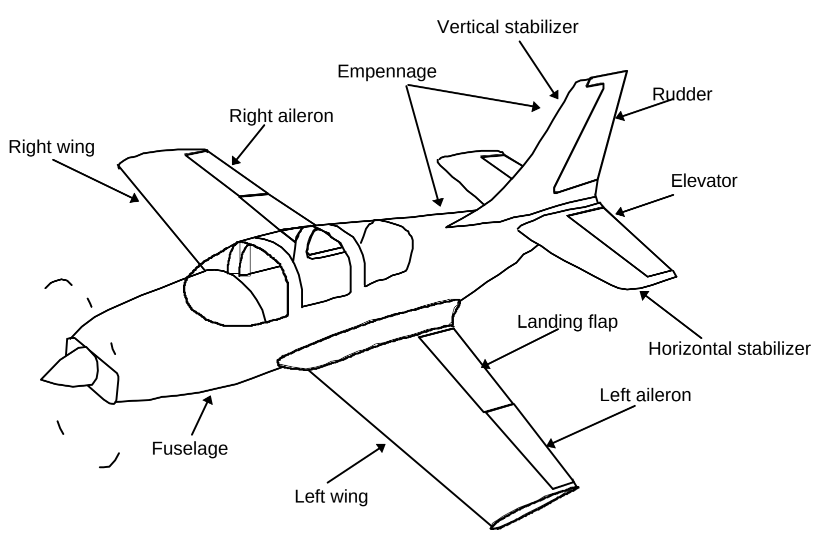


Figure 2-1

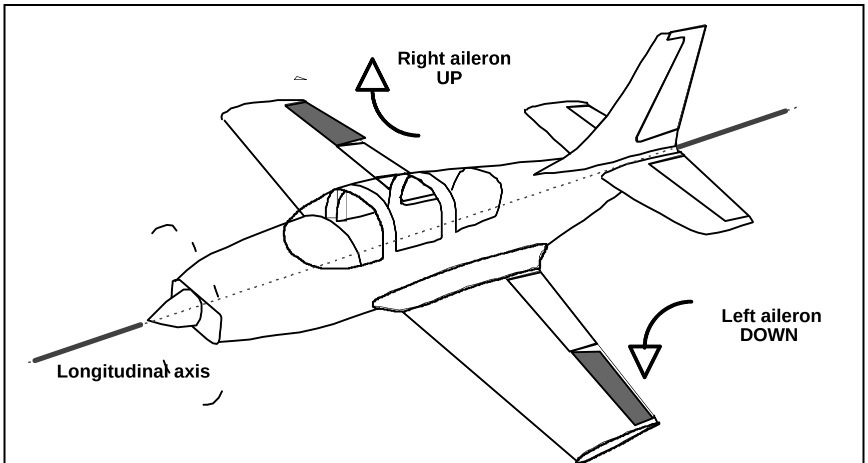


Figure 2-2

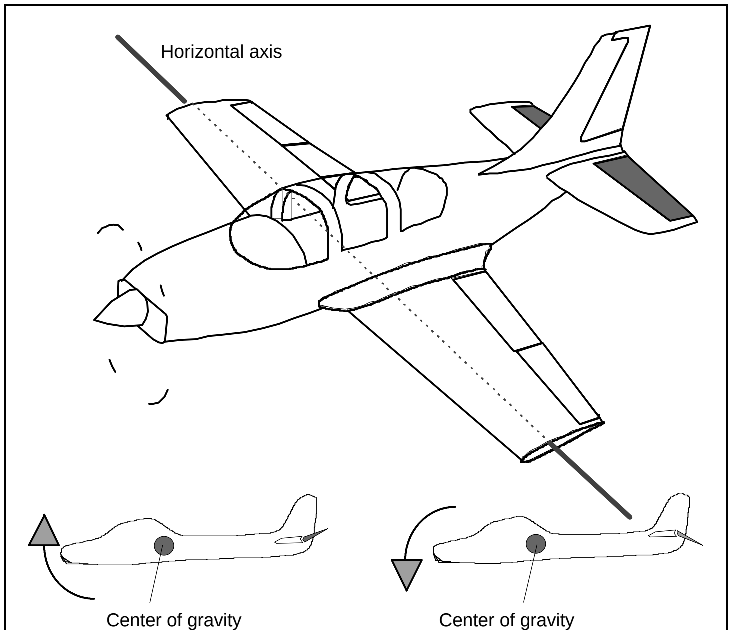


Figure 2-3

The basic structure of a conventional airplane is the fuselage, and all other parts are attached to it. This is true for most single-engine aircraft. The primary source of lift is the wing, while the other parts provide stability and control. The tail, or empennage, consists of the horizontal stabilizer with its attached elevators and the vertical stabilizer with its attached rudder.

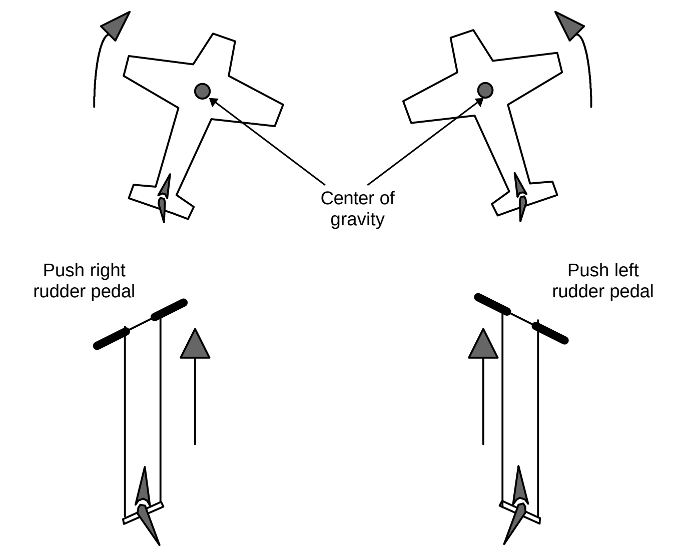


Figure 2-4

2.1.1 Ailerons

Ailerons are movable surfaces attached to the trailing edge of the wing, toward the wing tip from the flaps. They control roll or movement around the longitudinal axis (Figure 2-2). When the aileron on one wing goes down, the aileron on the other wing automatically goes up. If the pilot wants to roll to the right, he moves the stick or turns the yoke to the right. The right aileron goes up (creating a loss of lift on the right wing) and the left aileron goes down (creating more lift on the left wing), which results in a roll to the right.

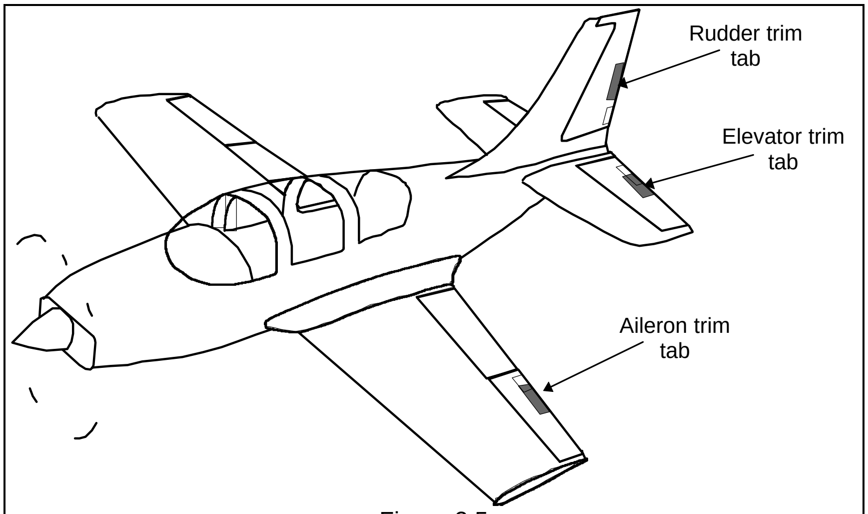


Figure 2.5

2.1.2 Elevator

An elevator is a control airfoil attached to the trailing edge of the tail's horizontal stabilizer. It controls pitch, or movement around the horizontal axis (Figure 2-3). When the yoke is pulled back, the elevators are raised. The raised elevators and the actions of relative winds cause a downward force on the tail and thus raises the nose. The relative wind causes an opposite action when the yoke is pushed forward by the pilot.

2.1.3 Rudder

The rudder is an airfoil attached at the trailing edge of the tail's vertical fin. It is designed to control the yawing, or side-to-side action around the vertical axis (Figure 2-4). The action is controlled through right and left pedals at the pilot's feet. If he pushes the left pedal, the rudder swings to the left. This action, along with the actions of relative winds, creates a force that pushes the tail to the right. The nose of the aircraft then moves (yaws) to the left.

2.1.4 Trim tabs

A trim tab is used for fine control. It is an auxiliary surface attached to trailing edges of airfoils (Figure 2-5). When a continuous but slight pressure on the controls is required for straight and level flight, the pilot might adjust a trim tab to get the proper balance and be free from exercising continuous control on a long, tiring flight. Small knobs or wheels in the cockpit are provided to effect some of these adjustments in flight. Other tabs are adjustable only when the aircraft is on the ground. If the pilot lands and reports tail, nose, or wing heaviness, the remedy might be an adjustment of the tabs according to the need. Trim tabs are sometimes combined in one way or another with balancing tabs and flying tabs.

This brief look at the basic structure of an airplane does not explain all there is to know about the control surfaces. With this familiarization you should be able to recognize these parts and understand in a general way how they function.

2.2 Aircraft instruments

2.2.1 Magnetic compass

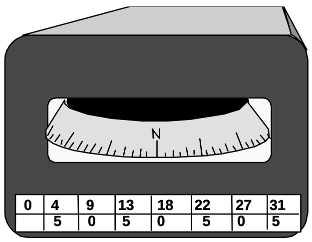


Figure 2-6

The magnetic compass (Figure 2-6) shows the aircraft's heading in relationship to the earth's magnetic North Pole. This instrument requires no power, so it can be used even in the event of complete electrical system failure. However, it is not as stable as gyro-driven heading indicators, and does not show heading well during turns. It also is affected by the metal structure of the aircraft and by the magnetic fields produced by electronic equipment. It is primarily used to calibrate the other heading systems and as a backup in case they fail.

2.2.2 Directional Gyro

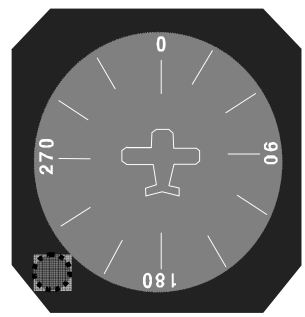


Figure 2-7

The directional gyro or heading indicator (Figure 2-7) is easier to use than the magnetic compass. Driven by a gyroscope, it provides a steady, reliable indication even during turns. Since gyroscopes can develop errors over time, this instrument must be aligned periodically during a flight. Normally aligned by the pilot manually, it may be automatically updated through a "slave" connection to a magnetic compass. The gyroscope that powers this instrument is usually driven by a vacuum pump, but it may be electrically powered.

Figure 2-8

2.2.3 Altimeter

The altimeter (Figure 2-8) shows pressure altitude, and is usually set to show altitude above Mean Sea Level (MSL). If the local barometric pressure is not set in the instrument, the altitude reading will not be correct.

2.2.4 Turn Coordinator

The turn coordinator (Figure 2-9) is two instruments in one. The miniature aircraft indicates the rate at which the aircraft is turning. The ball on the bottom is the slip indicator, which indicates whether the aircraft is flying straight or is yawed to one side or another.

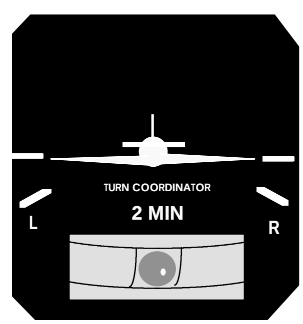


Figure 2-9

2.2.5 Airspeed indicator

Figure 2-10

The airspeed indicator (Figure 2-10) shows how fast the aircraft is moving through the air. It may be calibrated in statute miles per hour or in nautical miles per hour (knots). There are colored arcs around the outside of the dial indicating certain operating limits for the aircraft. These may include flap operating range, normal operating range, and maximum speed. Refer to the pilot's operating handbook for a complete description of the colored arcs and their meaning.

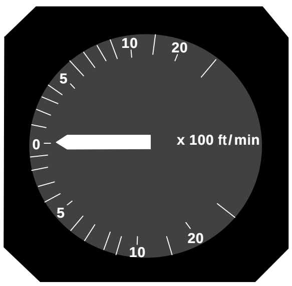


Figure 2-11

2.2.6 Vertical speed indicator

The vertical speed indicator (Figure 2-11) indicates the rate at which the aircraft is climbing or descending. It is usually calibrated in feet-per-minute. This instrument is most often used while flying in instrument conditions, but may also be referenced at other times. Because of its design, it has a 1- or 2-second lag before an accurate indication is displayed.

2.2.6A Attitude Indicator

The attitude indicator (Figure 2-12), sometimes called the "artificial horizon," is designed to show the attitude of the aircraft. It is primarily used in instrument flying.

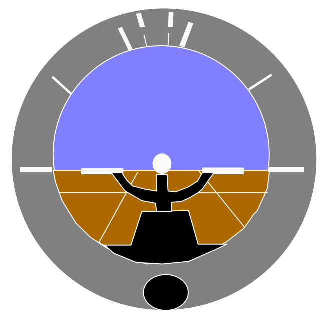


Figure 2-12

2.2.7 Engine instruments

Figure 2-13

Each aircraft may have a different set of engine instruments. These may include a tachometer to show engine speed in revolutions-per-minute (Figure 2-13), oil pressure gauge, oil temperature gauge, and cylinder head temperature to name a few. Many engine instruments have colored arcs to show normal operating ranges.

2.3 Weight and Balance

You will often hear the phrase "weight and balance" used in conjunction with preflight planning. Aircraft are designed to operate within specific design criteria, and exceeding these criteria can have devastating consequences. This section will discuss these issues in general terms. For information relating to weight and balance for a specific make and model of airplane, you should refer to the aircraft's flight manual.

2.3.1 Weight

The force of gravity continually attempts to pull the aircraft toward the ground. The only force that counteracts weight is lift. The amount of lift produced by an airfoil is limited by airfoil design, angle of attack, airspeed, and air density. Therefore, you must avoid overloading the aircraft to ensure sufficient lift is generated to counteract the weight. If aircraft weight exceeds the manufacturer's recommendations, the aircraft will be either unable to take off or it may exhibit unexpected and potentially lethal flight characteristics.

Every item on the aircraft contributes to its weight. Each aircraft is weighed after production and the figures are recorded in the maintenance log. When extra equipment, such as radios or other instruments, is added to the aircraft, the aircraft's weight is adjusted in the logbook. This figure is commonly referred to as "empty weight." For each flight, the pilot computes further increases in the weight for other items required for that flight. The first of these is oil and fuel for the engine. Aviation fuel weighs approximately 6 pounds per gallon, so this is a very important consideration. If a large load (i.e., people and luggage) must be carried in the aircraft, the pilot may elect to only partially fill the fuel tanks. This, of course,

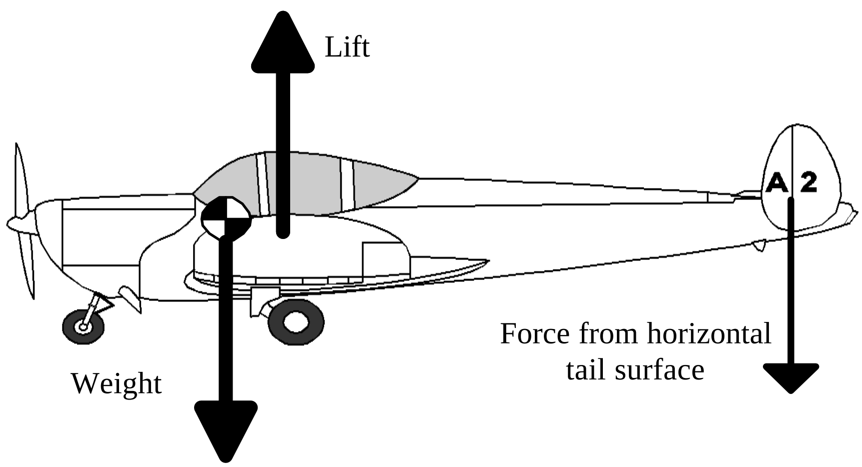


Figure 2-14

limits range and must be done very carefully because the fuel gauges are not very accurate.

2.3.2 Balance

Balance refers to the location of the center of gravity (c. g.) of an airplane and is critical to airplane stability and safety of flight. While gravity obviously affects the entire aircraft, for computations it can be assumed that the aircraft's weight is concentrated at the center of gravity. Figure 2-14 shows that gravity pulls down on the center of gravity, and the wings produce lift to counteract that force. The horizontal tail surface produces lift in a downward direction to balance weight and lift and keep the aircraft level. The pilot can change the force created by the horizontal tail by deflecting the elevator, which causes the nose of the aircraft to go up and down. The purpose of computing weight and balance before each flight is to ensure that the horizontal tail can generate enough lift to balance the aircraft and provide sufficient pitch control. The pilot controls the balance of the aircraft by calculating the center of gravity and loading the airplane to keep the c. g. within limits.

If the c. g. is not adjusted properly before flight, it can affect the stability of the aircraft. Modern civilian aircraft are designed to be stable in flight. This makes the aircraft safer and easier to operate. Positive pitch stability causes the aircraft to stay in a stable pitch attitude without constant manipulation of the controls, and pitch stability depends on the location of the c. g. in relationship to the center of lift. If the aircraft is loaded "tail heavy," the center of gravity will move aft toward the center of lift, and the aircraft will become less stable.

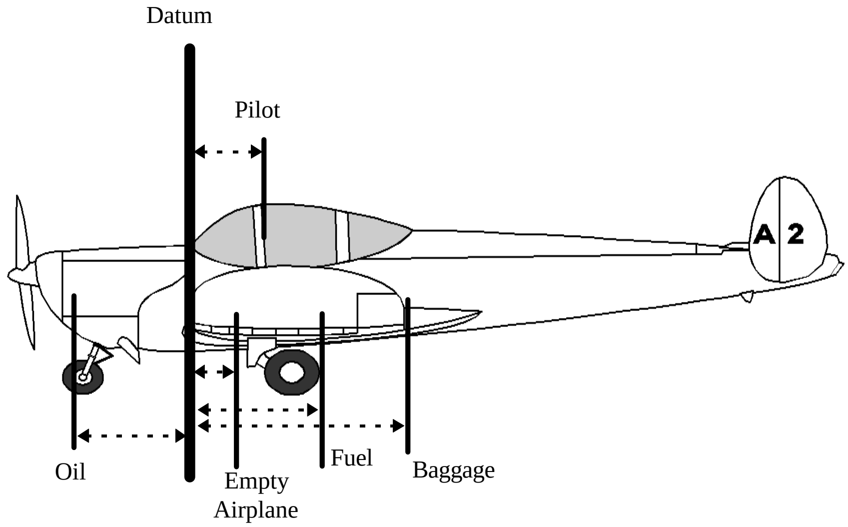


Figure 2-15

Incorrect balance can also affect the control of the aircraft. The elevator on the horizontal stabilizer is used to vary the force on the tail and thereby change the pitch attitude of the aircraft. If the aircraft is loaded "nose heavy," it could result in a condition where the horizontal tail surface cannot generate enough force to raise the nose. This is especially noticeable at the slow airspeeds that are used during takeoff and landing, and that is the worse possible time to discover you have a balance problem.

The manufacturer establishes C.G. limits. There are fore and aft limits beyond which the c. g. should not be located for flight. For some airplanes, the c. g. limits, both fore and aft, may be specified to vary as gross weight changes. They may also be changed for certain operations, such as acrobatic flight.

Every item in a balance problem has two components, a weight and a moment arm. Even the empty aircraft has both of these components. The moment arm is the item's distance from a specified point on the aircraft called the datum. In civilian aircraft the datum is often located at the aircraft's firewall, but that is not always the case. Figure 2-15 shows the parts of a typical balance problem. The pilot begins with the weight and moment arm of the empty airplane, then makes changes for the oil, fuel, passengers and baggage. The result must fall within the published limits for the aircraft, or something will have to be moved until the c. g. falls within those limits.

2.3.3 Computing weight and balance

Computing weight is very simple. The pilot starts with the documented empty weight of the aircraft and adds the weight of any items that are loaded for the flight. This figure should not exceed the published maximum gross weight for the aircraft.

Computing balance is a little more involved. Each item's weight and moment arm must be used to determine whether the loaded aircraft falls within the manufacturer's limits. Here's an example problem:

Item	Weight	Moment / 1,000
Empty airplane	1340	51.6
Oil	15	-0.3
Pilot and front passenger	320	11.2
Fuel	240	11.6
Rear seat passenger	300	21.6
Baggage	60	5.5
Totals	2,275	101.2

The moment for each item is determined using another chart in the aircraft manual. Then, the total weight and moment are used to enter the chart shown in Figure 2-16 and determine whether the aircraft is properly loaded. In this case, the aircraft falls within the c. g. envelope for normal operations.

Notice the moment arm for the oil is a negative value. This happens because

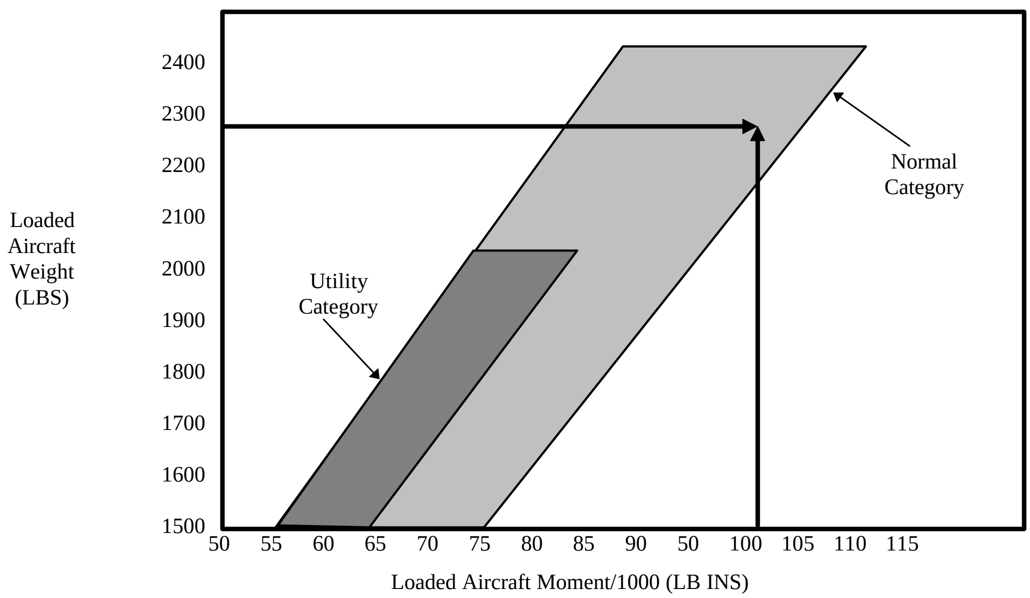


Figure 2-16

the datum for this aircraft is located at the firewall and the oil is located in the engine, which is in front of the firewall. The moment for the oil is subtracted from the total moment, and all other calculations proceed as normal.

2.4 Pre-flight inspection

The act of preflighting an airplane is no more than a safety check and evaluation of the craft's condition for the flight. This is the pilot's responsibility, and exactly how it is done will depend on the pilot's individual routine. Normally, the rest of the aircrew stands well clear as this preflighting process is carried out. If you are asked to help, you probably will call out each item on the checklist. When the pilot has examined the item called out she will give a signal such as "check" or "O.K." This means the pilot is ready for the next item to be called out. This method of checklist accomplishment is called “challenge and response.”

The walk-around inspection is the major portion of the pre-flight. Figure 2-17 shows the major parts of the aircraft that are included in the pre-flight inspection. A visual inspection will be made to see if any of the aircraft's major parts are defective. Condensation can occur in the fuel tanks, and water in the aircraft’s fuel can result in a reduction or complete loss of power. Aircraft fuel tanks have a drain at the bottom, and the pilot will extract a small amount of fuel from each tank and inspect it for contamination.

Fuel gauges sometimes malfunction, so a visual check of the fuel quantity is accomplished. The pilot removes the fuel filler caps and visually verifies that each

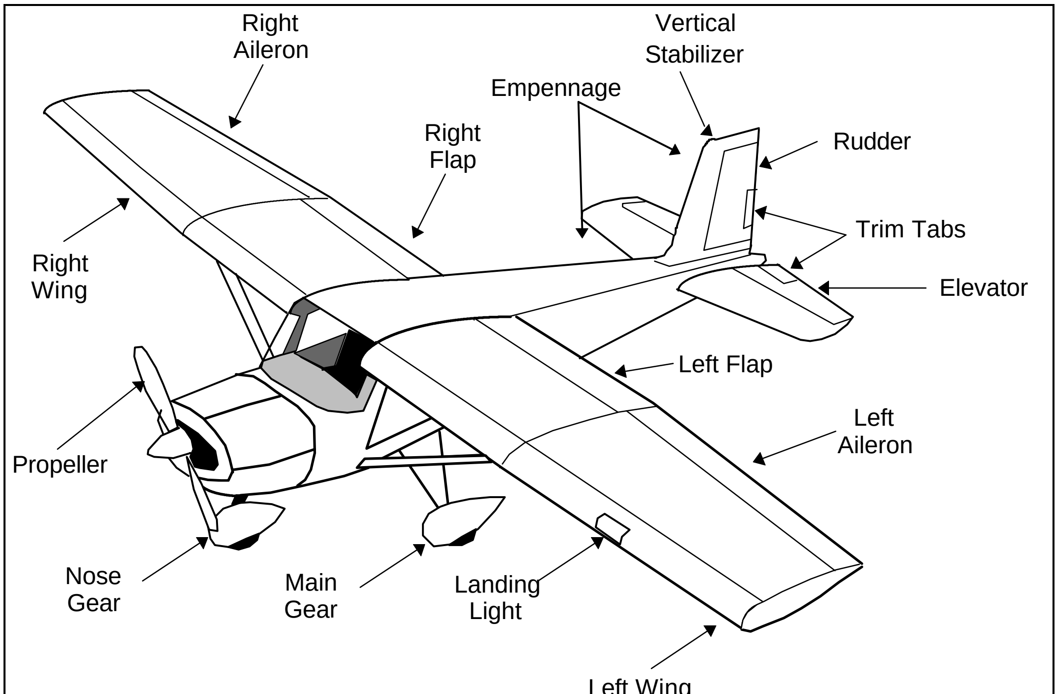


Figure 2-17

tank is filled (normal procedure is to fill the tanks upon completion of each sortie). As the walk-around continues, every movable, attached part will be tested for freedom of movement. Also, hinges will be scrutinized closely to see that they are fully in place and not worn thin.

The propeller and its attachment points receive careful attention. A large nick or hairline crack in a propeller could cause it to fail in flight. There are may other items to check as the pilot continues the walk-around inspection. When it is completed you will be instructed to board the airplane. Remember to fasten your seat belts and shoulder harness securely.

The preflight checks will continue after the crew is in the airplane. Other checklists are followed to start the engine, adjust radios and electronic navigation equipment (navaids), check flap settings, etc. This “before takeoff” checklist must be completed before taking the runway. This checklist is used to ensure that the engine is working properly, the controls are free, and that the control surfaces (ailerons, elevator, and rudder) are moving in the right directions. In addition to what is on the checklist, every pilot will take a last-minute look at certain items before the actual takeoff is started.

2.5 Safety

Safe activity in the vicinity of aircraft depends on everyone knowing certain “do's” and “don'ts.” Memorizing a list of what one should and should not do is desirable, but everything that could happen in a situation cannot be contained in a list. So, knowing certain basics is only a beginning; from this point on the person must remain observant and practice safety! Distractions and hurrying are part of a sure formula for mistakes.

In addition to remembering some very important do's and don'ts and thinking safety, it is good practice to be courteous. The Civil Air Patrol and individual aircraft owners who lend their craft to SAR missions have a lot of money invested. Remember that some of the equipment on aircraft is fragile, and all of it is expensive. Because of this, owners are very protective of their property. Your demonstration of respect for their property will cause them to accept you quickly as one of the team.

California Wing C-182 crashes; 2 killed, 1 injured

CALIFORNIA - Two California Wing members were killed and one injured Nov. 1 when the Civil Air Patrol C-182 they were flying crashed about 75 miles south of Reno, Nev. The two crew members who died in the crash were both assigned to the San Jose Senior Squadron out of San Jose, Calif.

Injured was Captain Joseph Smith, who was assigned to the Jon E. Kramer Composite Squadron out of Palo Alto, Calif. Captain Smith was found at the crash site and immediately transported to the University of California, Davis Medical Center in Sacramento. He was listed in fair condition with burns on his hands and face.

The aircrew was searching for a missing Cessna 206 with four on board when their aircraft went down in a remote wilderness area in the Toiyabe National Forest.

Civil Air Patrol News - November 1997

2.5.1 No smoking

You will see "No smoking within 50 feet" signs at aviation gasoline pumps. This distance is necessary because of the possibility of igniting gasoline fumes. Such signs will not be displayed on SAR aircraft, but the same rule applies. Why? All aircraft have fuel overflow pipes through which gasoline may spill onto the ground when heat causes it to expand. As the gasoline evaporates its fumes may travel in any direction. Therefore, an open flame anywhere near the airplane could cause the airplane to catch fire.

The best or safest precaution is to forget about smoking when you are anywhere near aircraft or gasoline pumps, or better yet, anytime you are on the flight line. There should be specially designated smoking areas at your mission headquarters. If so, use them. After all, they were designated for a special purpose - to avoid the loss of valuable property and, possibly, lives.

2.5.2 Keep clear

You should always remember that an aircraft that is moving on the ground (taxiing) is a dangerous vehicle. You could be injured if struck by any part of the airplane, but the propeller is a real killer. The propeller spins so rapidly it is invisible most of the time, and this may be part of the explanation of why so many people have been killed by propellers. Still another part of the explanation must be that the victims were not paying attention to what they were doing - they were not thinking!

The airplane does not have to be moving for its propeller to be spinning. When a pilot starts the engine the propeller starts spinning. Before the airplane begins to taxi, the pilot lets the engine run to "warm up" while he makes adjustments to radios and other items in the cockpit. The reverse process takes place when the airplane is brought in at the close of the sortie. The airplane is stopped, but the engine remains running, and the propeller spins until the pilot completes his post-flight checklist. Engine shutdown is one of the last items on this checklist, so the engine may run for several minutes after the airplane stops moving. Also, due to the design of an aircraft's electrical system, it is possible (although improbable) for an engine to start by itself. Therefore, it is safest to avoid touching or standing close to a stopped propeller.

Remember, keep well clear when an airplane is moving or when its engine is running. Always stay clear of the propeller, even if it is stopped. Do not enter or exit an aircraft while the propeller is spinning. Also, watch out for the trailing edges of the wings, flaps, and ailerons as they are sharp and are often right at head level. You should take extra care when moving around the aircraft and looking at some other item of detail.

2.6 Ground Operations

Aircraft, unlike automobiles and other vehicles, seem very flimsy to us. Actually they are <u>extremely</u> strong, but only when the loads and forces acting on them are applied in the amounts and directions for which their designers intended. Other forces and loads can easily cause minor or major damage to the aircraft. Due to the complexity of their structure, even minor damage can be very expensive to repair.

When ground handling and pushing an airplane, never push or pull on control surfaces or the propeller. Never push the aircraft at any point that has "No Push" painted on it. For the majority of CAP aircraft (C-172s and C-182s), use the struts to move the airplane (remember to check the brakes first).

Also, don't rotate, hold, or stand near the propeller. Aircraft ignition systems are designed differently from those in cars, and even slight propeller movement, especially when the engine is still warm, can sometimes cause the engine to "fire" momentarily, hurting anyone in the propeller's path. Few individuals survive being struck by a propeller.

When loading the aircraft, ensure all loose items are stowed or secured. In moderate to severe turbulence, loose objects in the airplane cabin can suddenly become projectiles that can hurt cabin occupants or damage the aircraft. If the aircraft is equipped with cargo nets or cargo straps, use them.

Be very careful where you step when boarding or exiting the aircraft. Most aluminum wing skin will *not* support the weight of even a small adult without dimpling or distorting. On low-wing aircraft, like the *Cherokee,* the portion of the wing that *will* support such weight is usually covered with black or gray nonskid material and is known as the wing walk. On high-wing aircraft, like single-engine Cessnas, never step on the pod or "pant" that covers each main wheel and tire assembly. Wheel pants and mounting supports are not designed to be used as steps, and will be bent or damaged if used as such. You may also see parts of the aircraft labeled “No Step” and “No Handhold.” It is very important to follow the warnings given by these placards.

Entering or exiting an airplane while the engine is running is highly discouraged. Exiting an aircraft while the propeller is moving is very dangerous, as you may slip and fall into the propeller. If you must board while the engine is running, make sure the pilot has you in sight and approach the airplane from behind the wing. Always remain in the pilot’s sight. Also, propellers can throw up dust and dirt even when spinning at idle power settings, so eye protection is recommended for those individuals that must board the airplane while its engine is running.

Always wear seat belts in the aircraft. FAA and CAP regulations require all occupants to wear seat belts and shoulder harnesses anytime the aircraft is moving on the airport surface, and during takeoff or landing. Once airborne, you may remove the shoulder harness, but it makes good sense to leave it loosely fastened in case unexpected turbulence is encountered. Also, don’t touch anything in the aircraft, especially knobs and switches, unless you are familiar with its purpose and use.

Using a headset is recommended for in-flight noise protection. If you don’t have a headset, use earplugs.

While taxiing the aircraft, all crewmembers should watch in all directions for any obstacles that might contact and damage the airplane, such as other airplanes, fuel trucks, signs, or fence posts. Frequently, in crowded parking areas, it may be necessary for the pilot to taxi the airplane near an obstruction. The crew should obtain the assistance of a "wing walker" or outside observer to visually confirm the airplane will clear the obstruction without contact. Ground crewmen use hand signals to help pilots during taxi operations. Those signals are located in CAPR 55-1, and can also be found at the end of this chapter.

All crewmembers must be alert to prevent the CAP aircraft from taxiing closely behind any large aircraft, either jet or prop, which has its engines running. Thrust produced by the operating engines, even at very low power settings, can blow a light airplane out of control or even tip it over. Rotor down wash from an operating helicopter can have similar disastrous effects.

2.6.1 Don't touch

Some of the courtesy we spoke of earlier can be extended to aircraft owners by never touching their aircraft. Looking and admiring is fine, but never touch an airplane unless the pilot or pilot/owner gives permission for you to do so. When inside the airplane, consider the "don't touch" rule to be doubled. This is especially true for any of the knobs, levers, and cranks. Many of these items have been set or adjusted for safe flight. If you move any of them and the pilot happens not to check them before flight, there could be some embarrassing moments for all. This "don't touch" rule will be relaxed as you become more familiar with the airplane. You will get a type of on-the-job training from the pilot. You may eventually be asked to help with the preflight and post-flight tasks.

As a general rule, the action to take in case of fire on the ground is to get away from the airplane. Whether you should run is a matter of judgment. After all, the fire may be a very small one that is confined to the engine compartment. If this is the case, the fire could be extinguished if action is taken quickly. Each airplane has a fire extinguisher on board, so make certain you know where it is located and you know how to operate it. Remember, however, to use your head. If there is a small fire, but gasoline is pouring out of the fuel tanks, and if it isn't necessary to help other members of the aircrew get away, you should get away from the aircraft as fast as safely possible.

2.6.2 Getting into and out of the airplane

Do not step on an aircraft's wing or other part where there is no black, non-skid material attached. Sometimes there won't be any non-skid material on what is clearly a step. If there is any doubt, ask the pilot. Also, the pilot probably will say where and when to exit the airplane after it has come to a full stop and the engine has been shut off.

Always approach airplanes from the rear for entry and depart toward the rear. Remember that the front of the airplane is the business end. This is where the dangerous propeller is located.

The first thing that one should do upon taking a seat in any aircraft is to adjust your seatbelt and shoulder harness. The seatbelt should remain fastened until the flight is completed and you are ready to get out of the airplane. In flight, especially low-level flight, there is most always some degree of air turbulence. You want to bounce through the air with the airplane. If the seat belt is not fastened you will find yourself bouncing around in the cockpit! Even when taxiing, there is the possibility of a sudden stop.

2.6.3 Fire

As a general rule, the action to take in case of fire on the ground is to get away from the airplane. Whether you should run is a matter of judgment. After all, the fire may be a very small one that is confined to the engine compartment. If this is the case, the fire could be extinguished if action is taken quickly. Each airplane has a fire extinguisher on board, so make certain you know where it is located and how to operate it. Remember, however, to use your head. If there is a small fire, but gasoline is pouring out of the fuel tanks, and if it isn't necessary to help other members of the aircrew escape, you should get away from the aircraft as fast as safely possible.

In summary, here are a few checklist items that can help increase the margin of safety during aircraft operations:

- Plan all flights carefully and completely.

- Brief passengers concerning normal and emergency procedures.
- File flight plans for all flights outside of local area.
- Do a thorough preflight inspection prior to each flight.
- Make sure you are using current checklists.

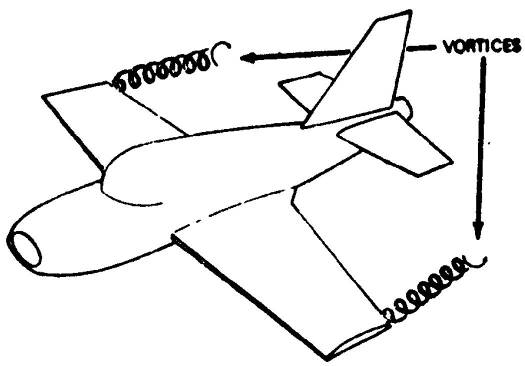


Figure 2-18

- Use standard hand signals during taxi operations.
- Chock main gear wheels fore and aft whenever the aircraft is parked.
- Make sure the aircraft is tied down at the end of each day, with the avionics/gust lock installed.
- Ground aircraft properly before refueling.
- Drain fuel tank sumps before flight.
- No smoking on the flight line.
- Know how to use safety equipment on and around aircraft.
- Know where the fire extinguisher is and how to use it.
- Have a fire extinguisher on the ground near the aircraft during refueling.
- Use seat belts while the aircraft is in operation.
- Know ramp procedures.
- Wear shoulder harness if they are installed in the aircraft.

2.7 Wake turbulence

Wake turbulence is the disturbance of air caused by a large airplane's movement and is sometimes called “used air.” This is a major cause for concern to all air crew members. It develops when normal air movement is disrupted by the motion of the aircraft structure, particularly at the wing tips. Higher pressure air beneath the wing continuously "spills" upward and around the tip to the lower pressure area above the wing. This creates a spiral vortex that, if visible, would resemble a horizontal tornado. Figure 2-18 depicts the generation of wing-tip vortices by an aircraft.

The amount of wake turbulence is directly related to the amount of lift the aircraft's wings must produce. All aircraft wings, even the lightest ones, produce some amount of wake turbulence, but it is not normally a danger unless the aircraft creating it is large, or heavy, and its wings are creating lift.

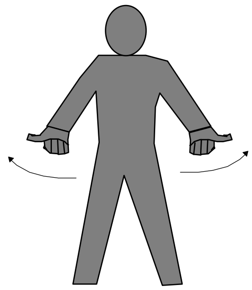
Vortex strength varies with the size, speed, and shape of the wing. Large or "jumbo" jets create the most severe wing-tip vortices when they are taking off or landing. In a no-wind condition, the vortices spread outward and away, and sink beneath the parent aircraft where normal atmospheric turbulence eventually disperses them. Vortices may remain active well after the aircraft that spawned them has passed. The duration of activity depends on the stability of the atmosphere at vortex level.

The FAA has studied wake turbulence and has published avoidance procedures for light aircraft pilots. The agency recommends that, when taking off behind a large jet, you wait several minutes for the vortices to disperse. The pilot should also make certain that the small plane lifts off the runway well before reaching the point where the jet's nose wheel lifted. This is because a large airplane does not generate strong vortices until its wings are making lift, which generally begins at nose wheel lift-off. When landing behind a large jet, the small plane should stay well above the jet's flight path and land beyond the jet's touchdown point. Once the jet's main and nose wheels are on the pavement, the wings produce only negligible lift and wing tip vortices.

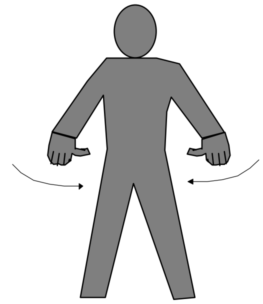
Operations from parallel runways can also be dangerous. Surface winds may blow wake turbulence into your path.

Wake turbulence is also a consideration to CAP aircrews while in flight, particularly when at low altitudes in the vicinity of an airport. Light aircraft must stay clear of the area behind and below the larger aircraft. The pilot of the smaller airplane should climb to an altitude above the large airplane's flight path. One thousand feet below the larger aircraft's flight path is considered safe vertical separation for avoiding wake turbulence. The pilot might consider descending more to allow for misjudging the large aircraft's altitude, if uncertain. If it's not practical to climb or descend, the light aircraft pilot should slow or turn the aircraft as required to increase the distance between his aircraft and the larger airplane.

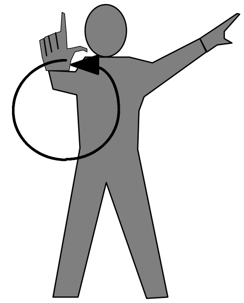
Air traffic controllers normally warn pilots of wake turbulence. They usually maintain 2-3 miles horizontal separation in flight, and require a three minutes wait for takeoff behind a heavy aircraft. However, it is the pilot’s final judgment to continue the takeoff or approach and landing.



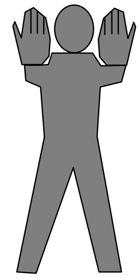
Outward motion with Thumbs - PULL CHOCKS



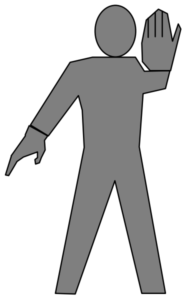
Inward motion with thumbs - INSERT CHOCKS



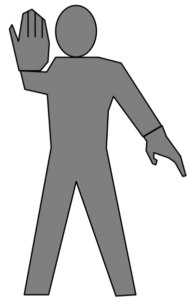
Circle with hand - START ENGINE



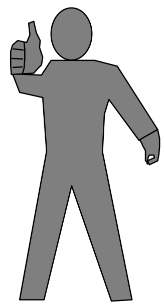
Hands out making a pulling motion - COME AHEAD



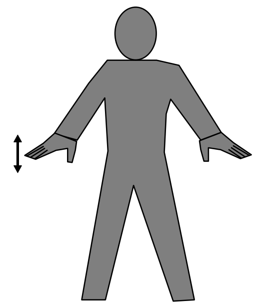
Motion forward, pointing left - TURN LEFT



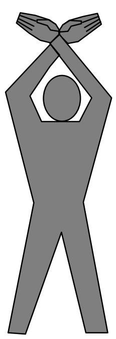
Motion forward, pointing right - TURN RIGHT



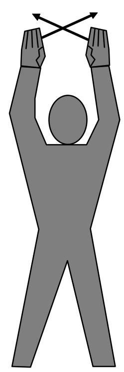
Thumbs up - ALL CLEAR - O.K.



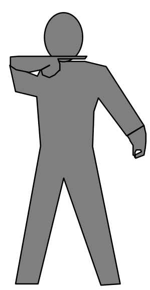
Downward motion with palms - SLOW DOWN



Hands crossed above head - STOP



Crossing hands over head - EMERGENCY STOP



Slash throat with finger - CUT ENGINE

1.1.1.1.1.2 Chapter

3

3. Survival and First Aid

Fundamental knowledge varies from region to region - depending on terrain, weather or other unique circumstances. When flying, assume the worst case scenario (e.g., depart Houston [flat, hot, humid] to fly to Alpine [mountainous, cool, dry]). Prepare thoroughly and include the items that you may need should an incident occur.

3.1 Survival equipment

As a minimum, aircraft on CAP flights should carry:

- First aid kit and manual.
- Water.
- Rations, such as MRE's (Meal Ready to Eat).
- Matches.
- Flotation device(s) if flying over water.
- Compass.
- Signal panels (CAPR 55-1, covered in coordination w/ GRD Teams).
- Signal mirror.
- Knife.

It's a very good idea to carry a personal survival kit. There is no official definition for the items in such a kit, but the following list could be considered the minimum essential items:

- High quality pocket knife with at least two cutting blades.
- Pocket compass.
- Plastic or metallic container.
- Waterproof kitchen-type matches (cushion heads against friction), or
- Waterproof matches rolled in paraffin-soaked muslin in an easily opened container such as small soapbox, toothbrush case, or match safe.
- Needles - sailmakers, surgeons, and darning - at least one of each.
- Assorted fishhooks in heavy foil, tin, or plastic holders.
- Sun block lotion, SPF 15 or greater.
- Snare wire - small shank.

- High-quality needle-nosed pliers with side cutters.
- Bar surgical soap or hand soap containing physohex.
- Small fire starter of pyrophoric metal (some plastic match cases have a strip of the metal anchored on the bottom outside of the case).
- Personal medicines.
- Water purification tablets.
- Bandages.
- Insect repellent stick.
- Chapstick.

In addition, here are some good-to-have items:

- Pen-gun and flares.
- Colored cloth or scarf for signaling.
- Stick-type skin dye (for camouflage).
- Plastic water bottle.
- Flexible saw (wire saw).
- Sharpening stone.
- Safety pins (several sizes).
- Travel razor.
- Small steel mirror.
- 6" flat bastard file.
- Aluminum foil.

There's never a shortage of ideas for survival equipment, but there's always a shortage of space. Depending on the amount of space you have available, here are some more ideas:

- Toothbrush - small type.
- Surgical tape.
- Prophylactics (make good waterproof containers and/or canteens).
- Penlight with batteries.
- Fishing line.
- Fishing line monofilament.
- Code card (Morse code).
- Emergency ration can opener (can be taped shut and strung on dog tag chain).
- Split shot - for fishing sinkers.
- Gill net.
- Small, high quality candles.

In addition to the first aid kit carried on the aircraft, you might consider the following items for an individual medical kit:

- Sterile gauze compress bandage.
- Anti-biotic ointment (Neomycin, polymycin, bacitracin, opthalmic ointment is good).
- Tincture of zephrine - skin antiseptic.
- Aspirin tablets.
- Salt tablets.
- If you “regularly” use medication, which is prescribed by your flight surgeon or physician, you should include an additional supply in your personal medical kit. This should be discussed with and procured from your personal physician.

3.2 Urgent care

If you are prepared to help others, you will be better able to care for yourself in case of injury. Even if your condition is so bad that you are unable to care for yourself, you can direct others in the correct procedures. The first, most important measures to take in the event of an accident are:

- Ensure the victim has an open airway and has a pulse.
- Control severe bleeding.
- Move the person if they are in a hazardous situation (e.g., fire, water, smoke, or toxic fumes).

The following procedures provide additional directions once emergency measures have been taken to ensure the victim's safety:

- Do not move the victim unless it is necessary for safety.
- Do not let the victim get up and walk around.
- Protect the victim from unnecessary manipulation and disturbance.
- Avoid or overcome chilling by using blankets or covers.
- Determine injuries.
- Administer required first aid.
- Plan actions according to the nature of the injury, the needs of situation and the availability of human and material resources.
- Remain in charge until the victim can be turned over to qualified persons.
- Know the limits of your capabilities and make every effort to avoid further injury to the victim in your attempt to provide the best possible emergency care.

1.1.1.1.1.3 Chapter

4

4. Communications

Airmen use several means to communicate, whether they are flying, taxiing, or stranded after an accident. Aerial communication has grown from simple techniques of dropping messages from airplanes to the use of highly sophisticated transceivers. In order to fulfill communication responsibilities involving the aircraft radios, mission observers must study basic communication techniques that are applicable to general aviation. This chapter will discuss radio communication techniques and examine other non-verbal communication methods that may be used when circumstances don't permit two-way radio use.

4.1 Electronic Communications

The aircraft radio (comm) is the primary means of communication in aviation. To effectively use the radio, mission observers must be knowledgeable of *how* to communicate and *when* communications are required. The techniques covered in this section were developed to improve clarity, to help keep communications transmissions brief, and as a means of giving words standardized meanings. Necessary communication should never be delayed while mentally searching for the appropriate terminology or phrase. If in doubt, always use plain language. Keep your radio transmissions clear, simple, and accurate. Practice using the radio so that you will be ready to go into action when the situation arises.

The discussion below covers communications with the air traffic control system, using the aircraft's comm radios. However, unlike most civilian aircraft, CAP aircraft also have a FM radio, which is used for mission-related communications, enabling us to communicate with mission base and ground units on different (non-ATC) frequencies. Most aircraft have a list of the assigned frequencies in the glove compartment.

Normally, the FM radio is operated by the observer. Its location, usually on the far right side of the front panel, makes it difficult for the pilot to operate. Operations vary for many aircraft, so you need to familiarize yourself with the operation of your aircraft's FM radio. You must possess a CAP Radio Operator Authorization card (CAPF 76) to operate this radio.

4.1.1 Using the aircraft radios

To establish radio communications, first tune the communications radio to the frequency used by the ground station. Almost all general-aviation aircraft transmitters and receivers operate in the VHF frequency range of 118.0 MHz to 136.975 MHz. Civil Air Patrol aircraft normally have 720-channel radios, and the desired frequency is selected by rotating the frequency select knobs until that frequency appears in the light-emitting diode display, liquid crystal display, or other digital frequency readout or window.

The 720-channel radios can be tuned in increments as small as 25 kilocycles, such as 119.725 or 119.775, by pulling the small knob (labeled "25 KC", lower right) outward. The last digit of the frequency will not be seen in the display (e.g., 119.775 is displayed as 119.77). Sometimes, for brevity, air traffic controllers assign such frequencies as "one-one nine point seven seven", meaning 119.775, not 119.770. The operator cannot physically tune the radio to 119.770, and this may be confusing.

Before transmitting, first listen to the selected frequency. An untimely transmission can "step on" another transmission from either another airplane or ground facility, so that *all* the transmissions are garbled. Many pilots have been violated for not complying with instructions that, it was later determined, had been blocked or "stepped-on" by another transmission. Next, mentally prepare your message so that the transmission flows naturally without unnecessary pauses and breaks. You may even find it helpful to jot down what you want to say before beginning the transmission. When you first begin using the radio, you may find abbreviated notes to be a convenient means of organizing your thoughts and using the proper terminology. As your experience level grows, you will no longer need to prepare using written notes.

Some radios have a design limitation that causes a slight delay from the instant the microphone is "keyed" until the radio actually starts transmitting. If you begin to speak before the radio has actually started to transmit, the first few syllables of the transmission will be lost. Until you become familiar with the characteristics of the individual radio, you may find it desirable to make a slight pause between keying the microphone and beginning to speak. When you are prepared to transmit, hold the microphone close to your mouth, and speak in a normal voice.

Normally, the initial transmission to a facility starts with the name of the facility you're calling, followed by your identification. You will usually identify yourself using your CAP flight designation (e.g., CAP Flight 4239). Once you've identified the facility and yourself, state your message.

4.1.2 Pronunciation

Radios do not always provide crystal clear sound. For example, 5 and 9, or B, D, T, and V may sound the same on a static-filled radio speaker. To minimize confusion, and to increase clarity, pronunciations of certain numbers and alphabetical characters used in radio transmissions have been accentuated.

Numbers are usually transmitted digit-by-digit, but there are some exceptions to that rule. For example, 10,000 is often transmitted as TEN THOUSAND, instead of ONE ZERO THOUSAND and radio frequencies are usually expressed like ONE TWENTY-EIGHT POINT ONE, instead of ONE TWO EIGHT POINT ONE.

Figure 4-1 provides a sample of how numbers are pronounced when using the radio.

Number	**Spoken As:**	**Number**	**Spoken As:**
0	ZERO	9	NINE ER
1	WUN	10	WUN ZERO
2	TOO	11	WUN WUN
3	THU REE	33	THU REE THU REE
4	FO WER	136	WUN THU REE SIX
5	FI YIV	500	FI YIV HUN DRED
6	SIX	1478	WUN FO WER SEVEN ATE
7	SEVEN	2100	TOO WUN ZERO ZERO
8	ATE	128.1	WUN TOO EIGHT POINT ONE

Figure 4-1

Like numbers, the letters of the alphabet carry distinctive traits of pronunciation. When it becomes necessary to spell difficult words, groups of words, or to identify any letter of the alphabet, the standard phonetic alphabet is used. The word to be spelled will be preceded by the words “I spell.” If the operator can pronounce the word to be spelled, do so before and after spelling the word.

You should express your callsign phonetically when calling, entering, reentering, joining, or rejoining a net, and when difficult operating conditions may result in confusion or mistaken identity. At all other times, phonetic expression of call signs is not required. Figure 4-2 shows the phonetic alphabet pronunciation for each letter.

Letter	Word	Pronunciation	Letter	Word	Pronunciation
A	Alpha	AL FAH	N	November	NOE VEM BER
B	Bravo	BRAH VOH	O	Oscar	OSS CAH
C	Charlie	CHAR LEE	P	Papa	PAH PAH
D	Delta	DELL TAH	Q	Quebec	KEH BEK
E	Echo	ECK OH	R	Romeo	ROW ME OH
F	Foxtrot	FOKS TROT	S	Sierra	SEE AIR AH
G	Golf	GOLF	T	Tango	TANG GO
H	Hotel	HOH TELL	U	Uniform	YOU NEE FORM
I	India	IN DEE AH	V	Victor	VIK TAH
J	Juliet	JEW LEE ETT	W	Whisky	WISS KEY
K	Kilo	KEY LO	X	X-Ray	EKS RAY
L	Lima	LEE MAH	Y	Yankee	YANG KEE
M	Mike	MIKE	Z	Zulu	ZOO LOO

Figure 4-2

4.1.3 Prowords

Prowords are pronounceable words and phrases that have been assigned a meaning for the purpose of expediting communications on radiotelephone circuits. Despite their economical uses, a proword, or combination of prowords should not be used to substitute in the text of the message if they will distort, change, or cause the actual meaning of the message to become unintelligible. Figure 4-3 contains a sample of prowords commonly used in radio communication.

TERM	DEFINITION or MEANING
AFFIRMATIVE	Yes.
ALL AFTER	The portion of the message to which I have reference is all that which follows.
ALL BEFORE	The portion of the message to which I have reference is all that which precedes.
BREAK	I hereby indicate the separation of the text from other portions of the message.
COPY	I understand.
CORRECT	You are correct, or what you have transmitted is correct
CORRECTION	An error has been made in this transmission. Transmission will continue with the last word correctly transmitted
DISREGARD	The last transmission was in error. Disregard it.
DISREGARD THIS TRANSMISSION	This transmission is in error. Disregard it. This proword should not be used to cancel any message that has been completely transmitted and for which receipt or acknowledgment has been received.
EXEMPT	The addresses immediately following are exempted from the

TERM	DEFINITION or MEANING
	collective call.
FIGURE(S)	Numerals or number follow.
FROM	The originator of this message is indicated by the address designator immediately following.
I READ BACK	The following is my response to your instructions to read back.
I SAY AGAIN	I am repeating transmission or portion indicated.
I SPELL	I shall spell the next word phonetically.
I VERIFY	That which follows has been verified at your request and is repeated. To be used only as a reply to VERIFY.
INFO	The addressees immediately following are addresses for information.
INITIALS	Personal initials shall be spoken phonetically prefixed by the word “INITIALS.”
MESSAGE FOLLOWS	A message which requires recording is about to follow. Transmitted immediately after the call. (This proword is not used on nets primarily employed for conveying messages. It is intended for use when messages are passed on tactical or reporting nets.)
MORE TO FOLLOW	Transmitting station has additional traffic for the receiving station.
NEGATIVE	No or “permission not granted” or “that is not correct”
OUT	This is the end of my transmission to you and no answer is required or expected.
OVER	This is the end of my transmission to you and a response is necessary. Go ahead; transmit.
PRIORITY	Precedence PRIORITY.
READ BACK	Repeat my message back to me. A request to repeat instructions back to the sender, for the purpose of confirmation. Also, the receiver's reply, repeating the instructions, as in: "Read back is as follows..."
RED CAP	Precedence RED CAP.
RELAY (TO)	Re-transmit this message to...
ROGER	I have received all of your last transmission. This should not be used to answer a question requiring a yes or no answer.
ROUTINE	Precedence ROUTINE.
SAY AGAIN	Repeat all of your last transmission. Followed by identification data means “Repeat ___________ (portion indicated).”
SPEAK SLOWER	Your transmission is at too fast a speed. Reduce speed of transmission.
SPELL, or I SPELL	Please spell, or "I shall spell the next word phonetically.”
STANDBY	I must pause for a few seconds.
THIS IS	This transmission is from the station whose designator immediately follows.
TIME	That which immediately follows is the time or date-time group of the message.
TO	The addressees immediately following are addressed for action.
VERIFY	Verify entire message (or portion indicated with) the originator and send correct version. To be used only at the discretion of or by the addressee to which the questioned message was directed.

TERM	DEFINITION or MEANING
WAIT	I must pause for a few seconds.
WAIT OUT	I must pause longer than a few seconds.
WILCO	I have received your signal, understand it, and will comply. To be used only by the addressee. Since the meaning of ROGER is included in that of WILCO, the two prowords are never used together.
WORD AFTER	The word of the message to which I have reference is that which follows _______.
WORD BEFORE	The word of the message to which I have reference is that which precedes ______.
WORDS TWICE	Communication is difficult. Transmit each phrase or each code group twice. This proword may be used as an order, request, or as information.

Figure 4-3

As an example of using phonetic letters and numbers, consider the following hypothetical example. [NOTE: ATC treats the CAP Flight callsigns like carrier airlines, so they do not spell out each number. For example, CAP Flight 4239 would be pronounced “CAP Flight FORTY-TWO THIRTY-NINE.”]

You want to fly an aircraft, CAP Flight 0123, through Restricted Area R-2403B, just north of Little Rock, Arkansas. You must verify the status of that area before proceeding and can do so with a transmission such as this:

"Memphis Center, CAP Flight ONE TWENTY-THREE requests flight through Restricted Area TWO FOUR ZERO THREE BRAVO to Fort Smith at NINER THOUSAND, FIVE HUNDRED if that airspace is not presently active."

If the area is not active, you might receive a reply like this from Memphis Center:

"CAP Flight ONE TWENTY-THREE, Memphis Center. Restricted Area TWO FOUR ZERO THREE BRAVO is not currently active. Proceed own navigation to Fort Smith."

Now that the controller has answered the request, you must make one final transmission so that the controller knows you have received and understood his instruction:

"Roger Memphis. CAP Flight ONE TWENTY-THREE is proceeding direct to Fort Smith at this time at NINER THOUSAND, FIVE HUNDRED."

In this communication exchange, both observer and controller were consistent in their messages. On the initial call-up, the observer first identified the facility being called, then identified her aircraft fully before transmitting the request.

The controller did the same, enabling both parties to know with certainty to whom each was speaking. Only when that positive identification has been established may the parties abbreviate the call sign, as in the observer’s final transmission as "CAP Flight ONE TWENTY-THREE".

4.1.4 Code words

Because the frequencies CAP normally uses are not secure, code words and phrases are sometimes used to prevent unauthorized parties from obtaining the information and possibly compromising mission integrity. The incident commander may assign code words and phrases for mission members to use when transmitting important mission information, such as the sighting of the target aircraft, its location, and whether there are survivors. These code words are entered onto your CAPF 104 during briefing.

IC/MCs ensure the codes provided to mission members are exact and complete enough to relay vital information. However, the observer must be sure all the following information is relayed, even when code words are being used:

- The fact that a sighting has been made.
- Location or position of the target in accordance with the grid, map, or chart that is standard to the mission.
- Any survivor information that is available.

Code words and phrases vary according to wing, mission and incident commander. In some cases, code words are not necessary.

4.1.5 Stuck mike

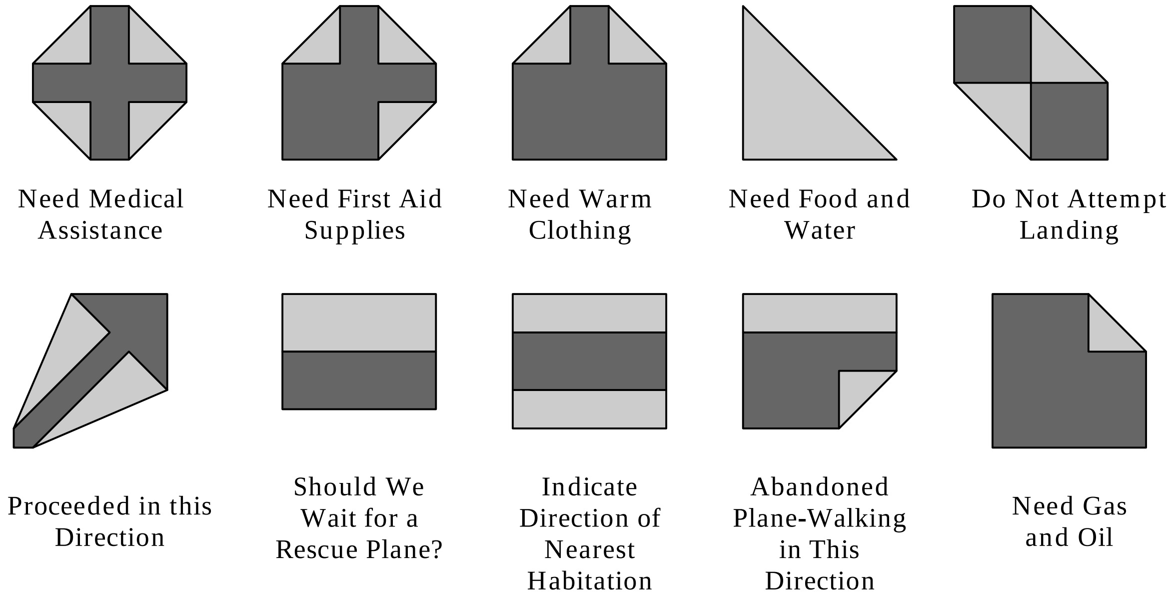
Occasionally, the transmit button on aircraft radio microphones gets stuck in the transmit position, resulting in a condition commonly referred to as a “stuck mike.” This allows comments and conversation to be unintentionally broadcast. Worse yet, it also has the effect of blocking all other transmissions on that frequency, effectively making the frequency useless for communication by anyone within range of the offending radio. You may suspect a stuck mike when, for no apparent reason, you don’t hear replies to your transmissions, especially when more than one frequency has been involved. Also, with experience you may notice a different sound quality to the background "silence" of the intercom versus the "silence" heard when the microphone is keyed but no one is talking. You may also notice the “T” symbol still illuminated in the radio’s display. Often the problem can be corrected by momentarily re-keying the microphone. If receiver operation is restored, a sticking microphone button is quite likely the problem.

4.2 Non-verbal communication

While you are on a mission, nonverbal signals may be the only available method of communication with a crash survivor or with ground teams. Mission observers may have to interpret these nonverbal messages and must be able to do so accurately regardless of the method used.

4.2.1 Light gun signals

If the radio in your aircraft fails, it is still very important for you to follow instructions from the tower on a controlled airport. In this case, you may have to rely on light gun signals from the control tower in order to receive the necessary landing and taxi clearances previously described. These clearance requirements still apply despite an inoperative radio. Figure 4-4 shows each light gun signal followed by its meaning.



Color and Type of Signal	**On the Ground**	**In Flight**
Steady Green	Cleared for takeoff	Cleared to land
Flashing Green	Cleared to taxi	Return for landing
Steady Red	Stop	Give way to other aircraft and continue circling
Flashing Red	Taxi clear of runway area	Airport unsafe—Do not land
Flashing White	Return to starting place on airport	Not applicable
Alternating Red and Green	General warning — exercise extreme caution	

Figure 4-4

4.2.2 Body signals

Use of the body is one of the most common means of sending messages. These signals are called "body signals" since they involve the whole body, not just arm movements. The are very easy to use because no special materials are needed. Body signals are shown on the last page of this chapter.

4.2.3 Paulin signals

“Paulin” is a short form of tarpaulin, which means waterproof canvas. If the victims of an accident are fortunate enough to have some paulin material, they may be able to aid the rescuers greatly by sending signals with it. It would be better if it were large and brightly colored. If the paulins are laid in clear areas wherein their colors cause high contrasts, they can be seen from substantial distances.

4.2.4 Emergency distress signals

The standard emergency distress signals shown in Figure 4-6 are another form of ground-to-air communication. These may be made from strips of fabric, pieces of wood, stones, wreckage parts, or any other available material. Each letter is two to three feet wide and six to twelve feet long, with colors that contrast with the background, if possible. Another use for these signals is to inform aerial searchers of ground team findings and intentions, in the absence of radio contact. A complete illustration and description of these signals is contained in CAPR 55-1.

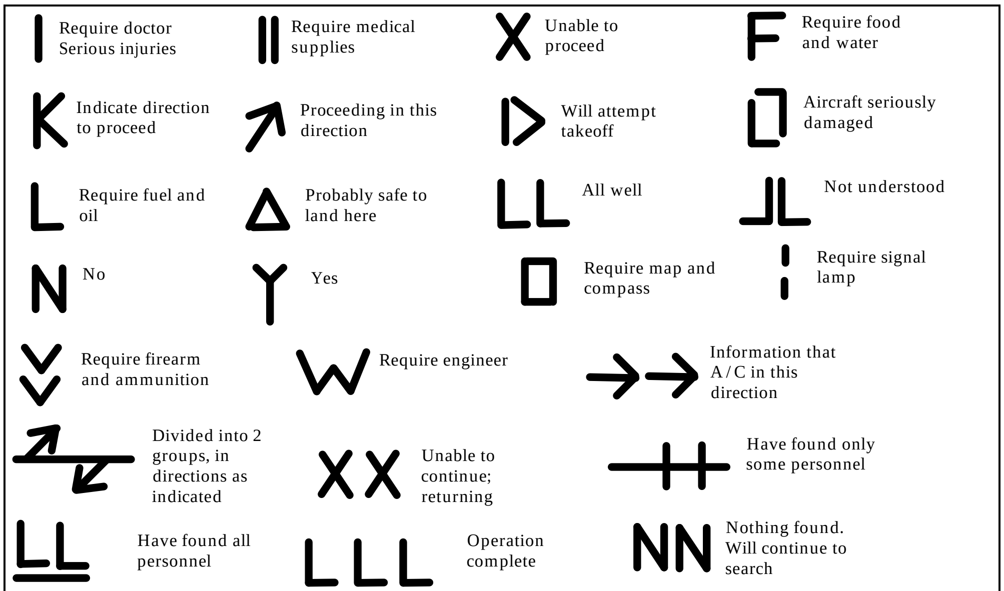


Figure 4-6

4.2.5 Air-to-ground signals

Communicating by radio is the basic air-to-ground communication method. If this isn't possible, the pilot has a limited number of signals that can be given using the aircraft itself, as illustrated in Figure 4-7. These signals serve as a standard means to acknowledge receiving and understanding signals from the ground. An "affirmative, I understand" response to a survivor's signal can often be a morale booster, and renew hope for imminent rescue.

In addition to the four signals shown in Figure 4-7, there are two more that aircrews use to communicate with ground rescue teams. First, if the crew believes a ground team should investigate an area, the pilot may fly over the team, "race" the engine or engines, and then fly in the direction the team should go. The pilot may repeat this maneuver until the ground team responds or until another means of communication is established.

Second, you may pinpoint an area for investigation by circling above the area, continuing to do so until the ground team reaches the area and begins the search. The better the communication from ground-to-air and air-to-ground, the more coordinated the search will be and the greater the chances for success.

4.3 In-flight services

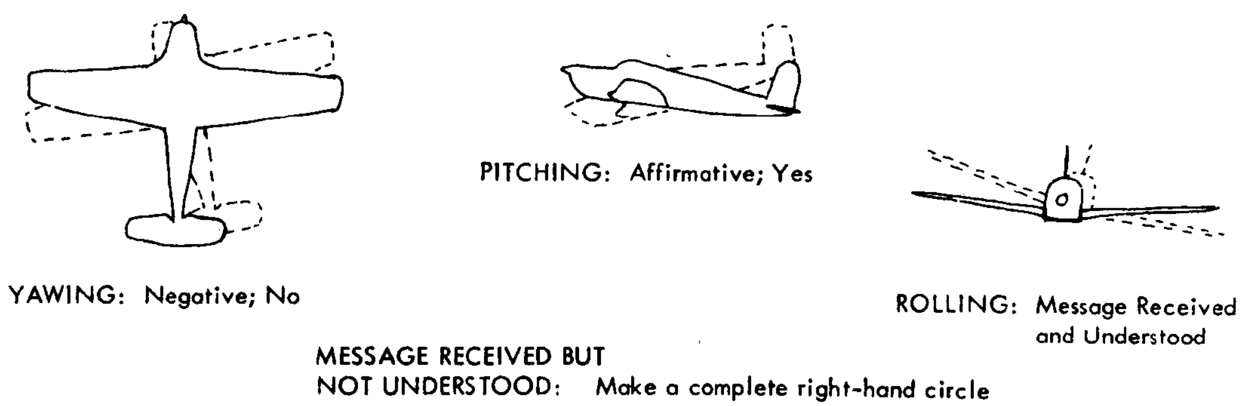


Figure 4-7

Whether you are participating in a training exercise or an actual SAR mission, the aircraft radio is an invaluable piece of equipment. Therefore, an understanding of the basic types of services that are provided through the radio is essential for mission observers.

You may call any FAA station along your route for any in-flight information or assistance, such as weather reports, special national weather service advice to aid in establishing your position, or locating an airport. It is not necessary to be completely familiar with all the standard terminology and procedures for air/ground communications. A brief call to any FAA station, stating your message in your own words, will get immediate attention. Personnel at FAA flight service stations are trained to help establish position by:

- Visual reference to terrain features.
- VHF omni-range indications (triangulation).
- Low-frequency radio range orientation.

4.3.1 Flight service stations

The FAA maintains a number of Flight Service Stations (FSS) that provide pre-flight and in-flight weather briefings, makes scheduled/unscheduled weather broadcasts, and gives weather advisories. Assistance may include providing Notices to Airmen (NOTAMs), weather forecasts, hazardous weather advisories, terminal weather observations, pilot reports, and other weather-related information.

Once airborne you can update weather information by contacting the Enroute Flight Advisory Service (Flight Watch) on 122.0, using the name of the air route traffic control center in whose airspace you are operating (e.g., Atlanta Flight Watch). Flight Watch provides time-critical assistance to enroute pilots facing hazardous or unknown weather, and may recommend alternate routes. Flight Watch also disseminates (and accepts) PIREPs. Other flight service frequencies are indicated on the sectional charts.

Flight service station personnel are also familiar with the general operating areas surrounding their respective facilities, and can be helpful in determining a pilot's position, should he become lost or disoriented. FSS personnel are also trained to help lost pilots establish their positions by VOR triangulation, and direction finding. These "lost pilot" services are intended to be used by pilots or crews who are genuinely lost, not those who are momentarily uncertain of their positions.

4.3.2 Transcribed Weather Broadcasts (TWEBs)

Selected FSSs have equipment that allows for meteorological and NOTAMS to be recorded on tapes and then broadcast continuously over selected NDBs and VORs. Broadcasts are made from a series of tape recordings and are updated as changes occur. The information varies from one station to the next, but usually includes at least the following:

- Synopsis and flight precautions.
- Route forecasts and outlook.
- Radar and Surface Weather Reports (area reports).
- Pilot reports.
- NOTAMs.
- Winds aloft data.

Notice that TWEBs are route-oriented and give <u>area</u> weather forecasts. In most cases, you must listen to TWEBs on the VOR or ADF receiver, using the same audio feature that was used previously to identify the station. The frequency of the transmission dictates which radio you have to use.

4.3.3 Scheduled Weather Broadcasts

All flight service stations having voice facilities on radio ranges (VOR) or radio beacons (NDB) that broadcast weather reports and Notice to Airmen information at 15 minutes past each hour from reporting points within approximately 150 miles of the broadcast station.

At each station, the material is scheduled for broadcast as available in this order:

- Alert notice announcement.
- Hourly weather reports.

- Weather advisory.
- Pilot reports.
- Radar reports.
- Notice to Airmen (NOTAMs, AIRADS-AIRMEN ADVISORIES).
- Alert notice.

Special weather reports and some notices to airmen data are broadcast off-schedule, immediately upon receipt. If you need special forecast services en route, you may obtain it from any flight service station. The time of observation of weather reports included in scheduled broadcasts is understood to be 58 minutes past the hour preceding the broadcast. When the time of observation is otherwise, the observation time is given.

Scheduled weather broadcasts (15 minutes past each hour) begin with the announcement "Aviation broadcast, weather." For example:

"AVIATION BROADCAST, WEATHER, OKLAHOMA CITY. OKLAHOMA CITY WILEY POST MEASURED CEILING ONE THOUSAND BROKEN, VISIBILITY TWO, FOG. TEMPERATURE FOUR THREE, DEW POINT FOUR ONE, WIND ONE NINER ZERO DEGREES AT FOUR. ALTIMETER TWO NINER EIGHT SEVEN." The completed broadcast is ended by saying, "THE TIME IS ONE EIGHT AND ONE QUARTER."

Reports for approximately 10 additional stations may follow. The local report is repeated as the last station report. Temperature is not broadcast, for other than the local report, when it is 40 degrees or less, or 85 degrees or higher.

When the temperature/dew point spread is 5 degrees or less, both the temperature and dew point are given. Surface wind direction and speed is given when it is 10 knots or more sustained. For this station, wind directions are magnetic, that is, measured from magnetic north rather than true north. The altimeter setting is given for the broadcast stations local report only. Special weather reports and advisories are broadcast when warranted by significant changes in the weather at a particular station or in a given area.

4.3.4 Automatic Terminal Information Service (ATIS)

At many airports, the FAA dedicates one or more transmitters and frequencies to continuous taped broadcasts of weather observations, special instructions, and NOTAMs that relate to the airport or nearby navigational facilities. ATIS tapes are intended to relieve air traffic controllers of repetitively transmitting the same data to every arriving and departing aircraft. Broadcast weather information is about actual observations for the smaller, terminal area -- not forecasts.

ATIS information is updated hourly, but may be updated sooner if the weather, special instructions or NOTAMs change significantly. Usually, you must listen to ATIS recordings on the communication radio. The frequency for the ATIS transmission is found on the sectional chart near the airport's name, or in a table on the reverse side of the sectional title panel. A typical ATIS transmission may sound like this:

"Atlanta Hartsfield Airport, arrival information 'November'. 2350 Zulu weather measured ceiling 800 overcast 1 1/2 miles in fog and haze. Temperature 16 degrees, dew point 15 degrees, wind calm, altimeter 29.80. ILS approaches in progress to Runways 8 left and 9 right. Landing runways 8 left and 9 right. Atlanta VOR out of service. Taxiway Mike closed between taxiways Delta and Sierra. Read back all 'hold short' instructions. Advise controller on initial contact you have information 'November'."

Even though you may not intend to stop at Hartsfield, this transmission contains bits of information that may have a significant bearing on your flight. The last weather observation, the wind, and the fact that the VOR is out of service could be very important to you. If you had any intention of using the Atlanta VOR for navigation assistance on your mission, you now know to make a different plan.

If you are conducting a search under visual flight rules that will take you in the vicinity of Hartsfield, you know to consider a new plan because the reported weather will not allow VFR flight. When cloud bases are more than 5,000 feet above the terrain and visibility is better than five miles, those portions of the weather observation may often be deleted from the broadcast.

4.3.5 In Flight Weather Broadcasts

When Flight Service receives severe weather forecast alerts from the National Weather Service, specialists transmit the alerts immediately and then again at each hour, half-hour, and quarter-hour for the first hour after the alert was first issued. The air traffic control centers also transmit the alert, but only once. Subsequent broadcasts may advise pilots to contact Flight Service to receive the alert text.

4.3.6 Hazardous In-Flight Weather Advisory Service (HIWAS)

You can also receive advisories of hazardous weather on the audio of many enroute navaids including VORs and NDBs. As the HIWAS name implies, this information relates only to hazardous weather, such as tornadoes, thunderstorms, or high winds. If no hazardous weather is reported, the crewmember will only hear the facility's identifier. Navaids having HIWAS broadcast capability are annotated on the sectional chart.

When receiving a hazardous weather report, ATC or FSS facilities initiate the taped HIWAS transmissions, and ATC then directs all aircraft to monitor HIWAS.

4.3.7 Automated Weather Observation System (AWOS)

At many airports, the FAA has installed Automated Weather Observation Systems. Each system consists of sensors, a computer-generated voice capability, and a transmitter. Information provided by AWOS varies depending upon the complexity of the sensors installed. Airports having AWOS are indicated on sectional charts by the letters AWOS adjacent to the airport name, and the level of information is indicated by a single digit suffix, as shown in Figure 4-8.

AWOS-A	Altimeter setting only
AWOS-1	Altimeter, surface wind, temperature, dew point, density altitude
AWOS2	Altimeter, surface wind, temperature, dew point, density altitude, visibility
AWOS-3	Altimeter, surface wind, temperature, dew point, density altitude, visibility, clouds/ceiling data

Figure 4-8

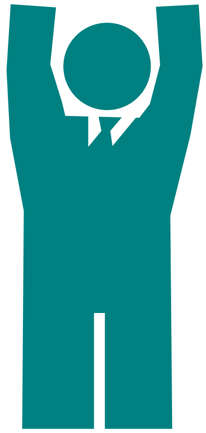
4.3.8 Pilot Weather Report (PIREP)

Pilot Reports (PIREPs) are often the only source of information about what's going on <u>between</u> weather stations. Since these reports are voluntary they may not be available for your flight, but always ask for them. CAP aircrews should submit PIREPs to Flight Watch whenever possible.

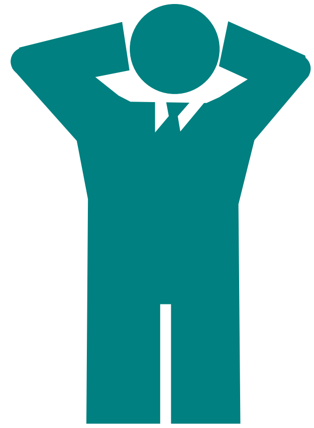
When submitting a PIREP you should state your location, the time, altitude, and aircraft type. Then give conditions such as sky cover, flight visibility, weather (e.g., cloud bases and tops, upper cloud layers, thunderstorms, ice, turbulence, or strong winds), temperature, wind, turbulence, icing and other significant flight information.

Federal Aviation Administration stations are required to solicit and collect pilot reports whenever ceilings are at or below 5,000 feet above the terrain, visibility is at or less than 5 miles, or thunderstorms, icing, wind shear, or turbulence is either reported or forecast. PIREPs are included at the beginning of scheduled weather broadcasts by FAA stations within 150 nautical miles of the area affected by potentially hazardous weather. These reports can help you avoid bad weather and warn you to be ready for potential hazards.

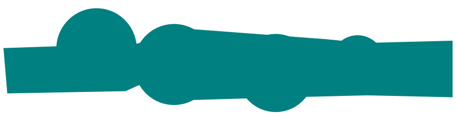
Wave Both arms across face
DO NOT ATTEMPT TO LAND



Both arms held over head
PICK UP - PLANE IS ABANDONED



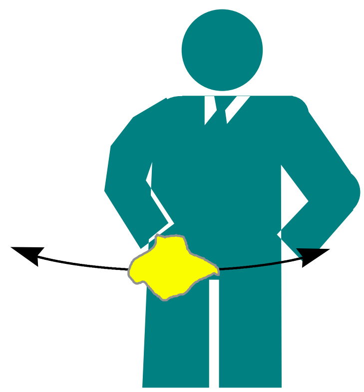
Cup hands over ears
OUR RECEIVER IS WORKING



Lie flat on back with hands above head
NEED MEDICAL ASSISTANCE

Both arms horizontal
NEED MECHANIC HELP or PARTS - LONG DELAY

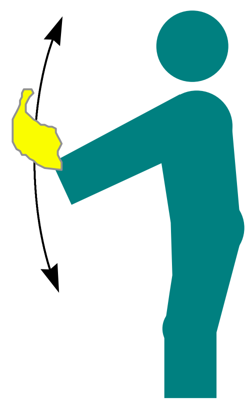
Wave one arm over head
ALL OK - DO NOT WAIT



Wave cloth horizontally
NEGATIVE – NO

One arm horizontal
CAN PROCEED SHORTLY WAIT IF PRACTICAL

Both arms pointing in the direction of landing while squatting
LAND IN THIS DIRECTION



Wave cloth vertically
AFFIRMATIVE – YES

1.1.1.1.1.4 Chapter

5

5. Weather

5.1 Basic weather

Since weather plays such an important part on any CAP operation, the mission observer must become familiar with some basic weather conditions. Your ability to interpret weather conditions may make the difference between returning safely to base or becoming the object of the search.

Importance of Weather

- Weather is the determining factor in safety of flight. It will determine whether or not a mission can be flown.
- Weather can be the determining factor in navigation (getting to the search area and actually conducting the search).
- Weather can have a pronounced effect on how you conduct the search.
- Weather is a significant factor in the effectiveness of a search. This is reflected by its inclusion on the CAPF 104.

Your understanding of weather conditions is very important. Weather invariably affects the effectiveness of CAP missions. Flying missions under low ceilings and during severe turbulence can prove to be a dangerous undertaking. Constant vigilance on your part is essential to mission success and aircraft safety.

5.1.1 Sources of weather information

Sources of Weather Information

- National Weather Service.
- Flight Service Stations.
- Pilots during flight (PIREP).

5.1.2 Atmospheric circulation

The factor that upsets the normal equilibrium is the uneven heating of the earth. The earth receives more heat at the equator than in areas to the north and south. This heat is transferred to the atmosphere, warming the air and causing it to expand and become less dense. Colder air to the north and south, being more dense, moves toward the equator, forcing the less dense air upward. This establishes a constant circulation that might consist of two circular paths, with the air rising at the equator, traveling aloft toward the poles, and returning along the

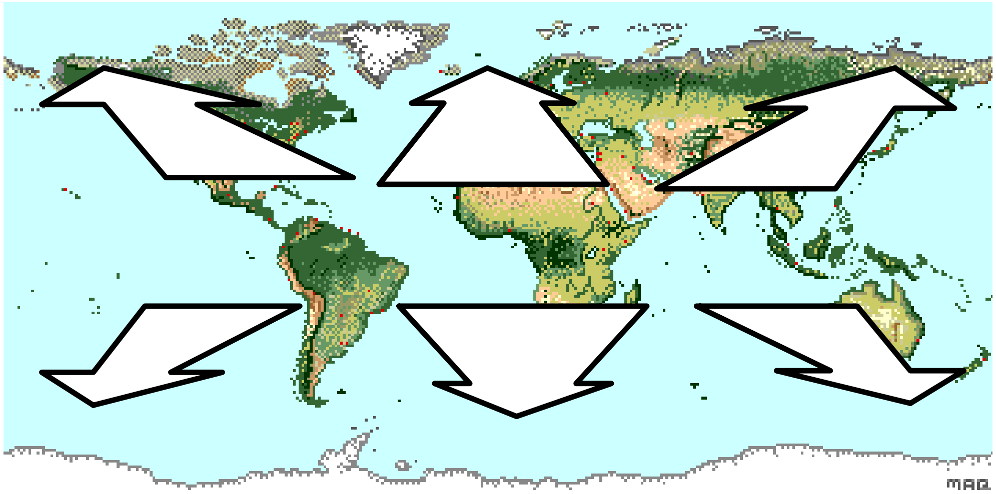


Figure 5-1

earth's surface to the equator. Heating at the equator would cause the air to circulate uniformly, as shown in Figure 5-1, if the earth did not rotate.

This theoretical pattern, however, is greatly modified by many forces. A very important one is the rotation of the earth. In the Northern Hemisphere, this rotation causes air to deflect to the right of its normal path. In the Southern Hemisphere, air is deflected to the left of its normal path. For simplicity, this discussion will be confined to the motion of air in the Northern Hemisphere.

As the air rises and moves northward from the equator, it is deflected toward the east, and by the time it has traveled about a third of the distance to the pole it is no longer moving northward, but eastward. This causes the air to accumulate in a belt at about latitude 30 degrees, creating an area of high pressure. Some of this air is then forced down to the earth's surface, where part flows southwestward, returning to the equator, and part flows northeastward along the surface.

A portion of the air aloft continues its journey northward, being cooled en route, and finally settles down near the pole where it begins a return trip toward the equator. Before it has progressed very far southward it comes into conflict with the warmer surface air flowing northward from latitude 30 degrees. The warmer air moves up over a wedge of colder air and continues northward, producing an accumulation of air in the upper latitudes.

Further complications in the general circulation of the air are brought about by the irregular distribution of oceans and continents, the relative effectiveness of different surfaces in transferring heat to the atmosphere, the daily variation in temperature, the seasonal changes, and many other factors.

Regions of low pressure, called “lows,” develop where air lies over land or water surfaces that are warmer than the surrounding areas. In India, for example, a low forms over the hot land during the summer months, but moves out over the warmer ocean when the land cools in winter. Lows of this type are semi-permanent, however, and are less significant to the pilot than the “migratory cyclones” or “cyclonic depressions” that form when unlike air masses meet. These lows will be discussed later.

5.1.3 Convection currents

Certain kinds of surfaces are more effective than others at heating the air directly above them. Plowed ground, sand, rocks, and barren land give off a great deal of heat, whereas water and vegetation tend to absorb and retain heat. The uneven heating of the air causes small local circulations called "convection currents," which are similar to the general circulation just described.

This is particularly noticeable over land adjacent to a body of water. During the day, air over land becomes heated and less dense. The colder air over water moves in to replace it, which forces the warm air aloft and causes an on-shore wind. At night the land cools, and the water is relatively warmer. The cool air over the land then moves toward the water as an off-shore wind, lifting the warmer air and reversing the circulation.

Convection currents cause the bumpiness experienced by pilots flying at low altitudes in warmer weather. On a low flight over varying surfaces, the pilot will encounter updrafts over pavement or barren places and down drafts over vegetation or water. Ordinarily, this can be avoided by flight at higher altitudes. When the larger convection currents form cumulus clouds, the pilot will invariably find smooth air above the cloud level.

Convection currents also cause difficulty during landings since they affect the rate of descent. Figures 5-2 and 5-3 show what happens to an aircraft on a landing approach over two different terrain types. The pilot must constantly correct for these affects during the final approach to the airport.

The effects of local convection, however, are less dangerous than the turbulence caused when wind is forced to flow around or over obstructions. The only way for the pilot to avoid this invisible hazard is to be forewarned, and to know where to expect unusual conditions.

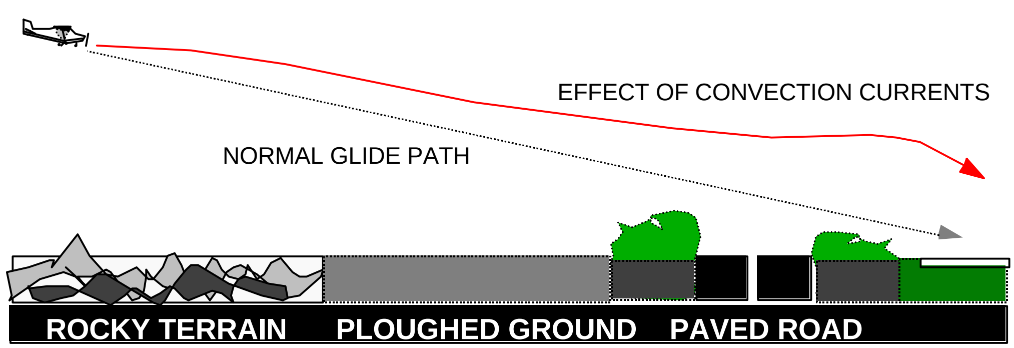


Figure 5-2

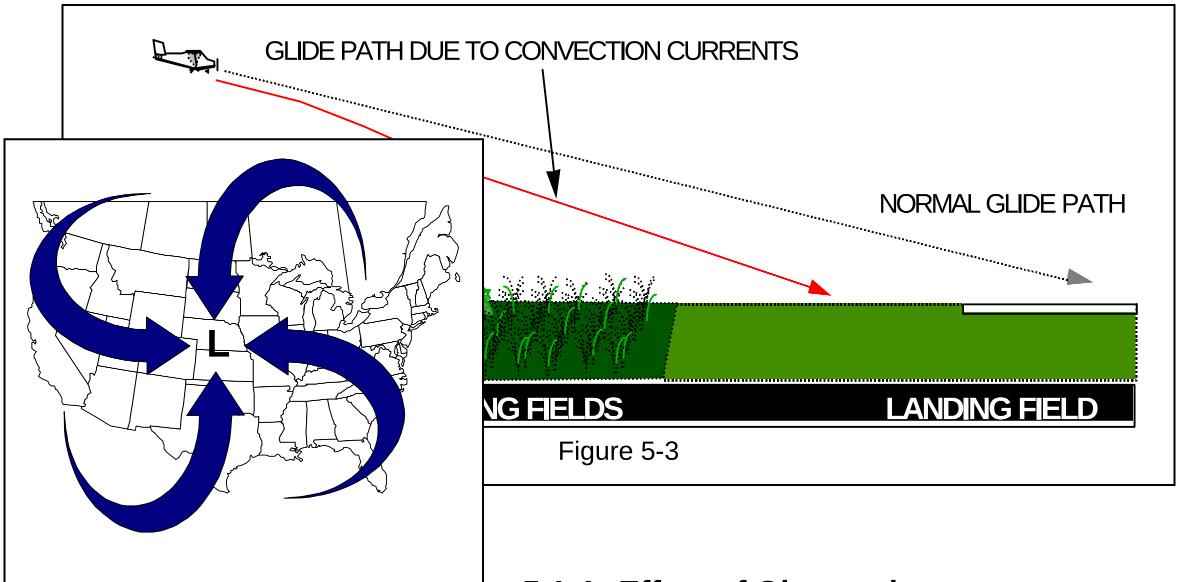


Figure 5-3

5.1.4 Effect of Obstructions on Wind

When the wind flows around an obstruction it breaks into eddies or gusts, with corresponding sudden changes in speed and direction. These effects may be felt some distance from the obstruction. The intensity of this turbulence depends on the size of the obstacle and the wind velocity, and it can present a serious hazard during takeoffs and landings. For example, during landings it can cause a pilot to “drop-in” and during takeoffs it can prevent the aircraft from gaining enough altitude to clear obstacles in its path. A pilot flying into such conditions must anticipate these effects and compensate accordingly.

This same condition is more noticeable where larger obstructions such as bluffs or mountains are involved. The wind blowing up the slope on the windward side is relatively smooth and its upward current helps to carry the aircraft over the peak. The wind on the leeward side, following the terrain contour, flows downward with considerable turbulence and would tend to force an aircraft into the mountain side. The stronger the wind, the greater the downward pressure and the accompanying turbulence. Consequently, in approaching a hill or mountain from the leeward side, a pilot should approach at a 45° angle and with enough altitude to safely clear the obstacle. Because of these downdrafts, it is recommended that mountain ridges and peaks be cleared by at least 2,000 feet. If there is any doubt about having adequate clearance, the pilot should turn away at once and gain altitude.

Between hills or mountains, where there is a canyon or narrow valley, the wind will generally veer from its normal course and flow through the passage with increased velocity and turbulence. A pilot flying in such terrain needs to be alert for wind shifts and particularly cautious when landing.

5.1.5 Winds around pressure systems

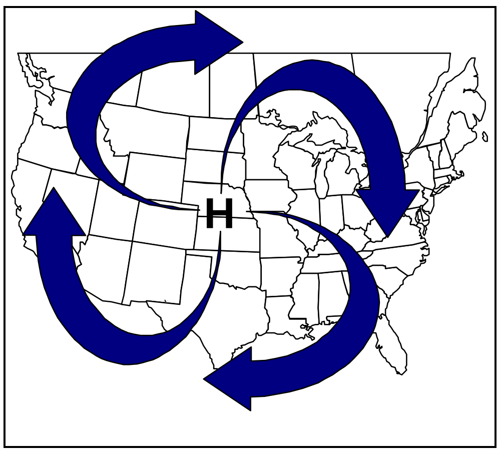
Certain wind patterns can be associated with areas of high and low pressure. As previously stated, air flows from areas of high pressure to areas of low pressure. In the Northern Hemisphere the air is deflected to the right because of the rotation of the earth. Therefore, as the air leaves the high-pressure area, it is deflected to produce a clockwise circulation. As the air flows toward low pressure it is deflected to produce a counterclockwise flow around the low-pressure area.

Another important aspect is that air moving out of a high depletes the quantity of air, creating an area of descending air. Since descending air favors the dissipation of clouds, highs are associated with good (clear) weather.

By similar reasoning, when air converges into a low-pressure area it cannot go outward against the pressure gradient, nor can it go downward into the ground; it must go upward. Rising air is conducive to cloudiness and precipitation, thus the general association of bad weather with lows.

Understanding these patterns frequently enables a pilot to plan a course to take advantage of favorable winds, particularly during long flights. In flying from east to west, for example, the pilot will find favorable winds to the south of a high, or to the north of a low. It also gives the pilot a general idea of the type of weather to expect relative to the “highs” and “lows.”

5.2 Icing



5.2.1 Freezing level

As altitude increases, temperature decreases at the fairly uniform rate of 2° Celsius (3.6° F) per 1000 feet. This rate of temperature change is known as the *lapse rate*. At some altitude, the air temperature reaches the freezing temperature of water, and that altitude is known as the *freezing level*. You can estimate the freezing level prior to flight by using simple mathematics. For example, if the airport elevation is 1,000 feet and the temperature at ground level is 12° Celsius, the freezing level would be at approximately 6,000 feet above ground level (AGL) or 7,000 feet above mean sea level (MSL). Since the lapse rate is 2° per thousand feet, it would take 6,000 feet of altitude to go from 12° Celsius to 0°, the freezing temperature of water. The same technique works for Fahrenheit, but you use 3.6° for the lapse rate. Don’t forget to include the airport elevation in your computations—altimeters are normally set to display MSL rather than AGL altitude. This method yields a very approximate value for the freezing level. You are encouraged to leave a wide margin for error above and below this altitude if you must fly through visible moisture during a search.

5.2.2 Airframe icing

When the ground cools at night, the temperature of the air immediately adjacent to the ground is frequently lowered to the saturation point, causing condensation. This condensation takes place directly upon objects on the ground as dew if the temperature is above freezing, or as frost if the temperature is below freezing.

Dew is of no importance to aircraft, but frost can be deadly. Normally we think of frost as unimportant -- it forms on cars or other cold surfaces overnight and usually melts after the sun rises. However, frost on an airfoil disturbs the airflow enough to reduce lift and efficiency. An airplane *may* be able to fly with frost on its wings, but even with the airflow over the wings only slightly disrupted, controllability can become unpredictable. **Frost should always be removed before flight.**

Ice can also accumulate on aircraft during flight, and this icing is a major problem. It is difficult to forecast, because under apparently identical situations the icing intensity on the aircraft can vary considerably. The ice accumulation rate may vary from less than one-half inch per hour to as high as one inch in a minute for brief periods. Experiments have shown that an ice deposit of one-half inch on the leading edge of some types of airfoil presently in use will reduce their lift by about 50%, increase the drag by an equal percentage, and greatly increase the stalling speed. Obviously, the consequences of ice accumulations can be very serious.

There are two fundamental requisites for ice formation on an aircraft. First, the aircraft must be flying through visible water in the form of rain or cloud droplets; and second, when the liquid water droplets strike, their temperature or the temperature of the airfoil surface must be 32 degrees F. or below. [Water droplets cooled below 32 degrees F. without freezing are called supercooled water droplets. They often exist in clouds when the temperature within the clouds is below 32 degrees F.]

Clear ice is a transparent or translucent coating of ice which has a glassy surface appearance. When transparent, it looks like ordinary ice, and is identical with the “glaze” which forms on trees and other objects when freezing rain falls to earth. It can be smooth or stippled. However, when mixed with snow, sleet, or hail it may be rough, irregular and whitish. It adheres very firmly to the surfaces upon which it forms and is very difficult to remove. Glaze usually forms on leading edges more or less in the shape of a blunt nose and spreads back, tapering along the wings. When deposited as a result of freezing of super-cooled raindrops or large cloud droplets unmixed with solid precipitation, it can be quite smooth and approximate a streamline form. When mixed with solid precipitation, the deposit can become especially blunt-nosed and rough, with heavy protuberances.

Rime ice is a white or milky, opaque, granular deposit of ice that accumulates on aircraft leading edges (including antennas) and projects forward into the air stream. Its surface is ordinarily rough. It has a granulated, crystalline or splintery structure. Wherever particles of supercooled water impinge on surface projections of the aircraft, such as rivet heads, the deposit acquires the form of a bulge which may cling rather firmly to the projecting parts.

When ice forms on an aircraft it can affect the flying characteristics in several ways:

- Lift is decreased. This is caused by a change in airfoil shape when ice accumulates on the leading edges. The aircraft will stall at air speeds well above the normal stalling speed.
- Weight is added. Clear ice can add substantial weight to an aircraft. The added weight increases lift requirements and increases drag. This is what makes the added weight of ice so dangerous.
- Drag is increased. This results when rough ice forms in back of the leading edges and on protuberances.

- Propeller efficiency is decreased. Uneven ice deposits on the blades cause vibration and blade distortion with consequent loss of effective power. Under icing conditions, all available power may be needed.

When flying in regions of possible icing condition, plan your flight so as to be in the region for the shortest possible time:

- Caution should be exercised when flying through rain or wet snow when the temperature at flight levels is near freezing.
- When flying into clouds above the crest of ridges or mountains, maintain a clearance of 4,000 or 5,000 feet above the ridges if the temperature within the cloud is below freezing. Icing is more probable over the crest of ridges than over the adjacent valleys.
- Watch for ice when flying through cumulus clouds when the temperature at flight level is near freezing.
- When ice forms on the aircraft, avoid maneuvers that will increase the wing loading.
- Remember that fuel consumption is greater when flying under icing conditions, due to increased drag and the additional power required.
- Consult the latest forecasts for expected icing conditions.

5.2.3 Carburetor icing

Although not directly related to weather, another problem is carburetor icing. As air is drawn through the carburetor venturi, it expands and cools. Moisture in the air can condense and freeze, blocking the flow of air and fuel to the engine.

Unlike aircraft structural icing, the aircraft does not need to be in visible moisture and the air temperature does not need to be near freezing for carburetor ice to form. Since it’s moisture in the air that condenses and freezes, airplanes are most vulnerable to carburetor icing when operated in high humidity. In the summer this can occur at altitudes below 10,000 feet with air temperatures as high as 77 degrees F.

Normally, an airplane engine develops sufficient heat at climb and cruise power settings to keep carburetor ice from forming. It's most likely to become a problem when the aircraft is operated at low power settings, such as in descents and approaches to landings.

Many manufacturers have provided a means for selectively ducting warm air to the carburetor to prevent icing when operating at low power settings. This feature is called *carburetor heat,* and the pilot may select it when starting a low-power descent. Fuel-injected engines are not vulnerable to carburetor icing.

5.3 Frontal activity

Large high-pressure systems frequently stagnate over large areas of land or water with relatively uniform surface conditions. They take on characteristics of these “source regions” -- the coldness of polar regions, the heat of the tropics, the moisture of oceans, or the dryness of continents.

As air masses move away from their source regions and pass over land or sea, they are constantly being modified through heating or cooling from below, lifting or subsiding, absorbing or losing moisture. Actual temperature of the air mass is less important than its temperature in relation to the land or water surface over which it is passing. For example, an air mass moving from polar regions is usually colder than the land and sea surfaces over which it passes. On the other hand, an air mass moving from the Gulf of Mexico in winter usually is warmer than the territory over which it passes.

If the air is colder than the surface, it will be warmed from below and convection currents will be set up, causing turbulence. Dust, smoke, and atmospheric pollution near the ground will be carried upward by these currents and dissipated at higher levels, improving surface visibility. Such air is called "unstable." Conversely, if the air is warmer than the surface, there is no tendency for convection currents to form and so the air is smoother. Smoke, dust, and pollution are concentrated at lower levels with resulting poor visibility. Such air is called "stable." From the combination of the source characteristics and the temperature relationship just described, air masses can be associated with certain types of weather.

Characteristics of a cold, unstable air mass are:

- cumulus and cumulonimbus clouds.
- unlimited ceilings (except during precipitation).
- excellent visibility (except during precipitation).
- pronounced turbulence in lower levels because of convention currents.
- occasional local thunderstorms or showers, hail, sleet, and snow flurries.

Characteristics of a warm, stable air mass are:

- stratus and stratocumulus clouds.
- generally low ceilings, fog, haze.
- poor visibility (smoke and dust held in lower levels).
- smooth air with little or no turbulence.
- slow steady precipitation or drizzle.

When two air masses meet they will not mix readily unless their temperatures, pressures, and relative humidities are very similar. Instead, they set up boundaries called frontal zones, or "fronts." The colder air mass projects under the warmer air mass in the form of a wedge.

Usually the boundary moves along the earth's surface, and as one air mass withdraws from a given area it is replaced by another air mass. This action creates a moving front. If warmer air is replacing colder air, the front is called "warm"; if colder air is replacing warmer air, the front is called "cold." If the boundary is not moving, it is termed a "stationary front."

5.3.1 Warm Front

When a warm front moves forward, the warm air slides up over the wedge of colder air lying ahead of it.

Warm air usually has high humidity. As this warm air is lifted its temperature drops. Condensation occurs as the lifting process continues, nimbostratus and stratus clouds form, and drizzle or rain develops. The rain falls through the colder air below, increasing its moisture content so that it also becomes saturated. Any reduction of temperature in the colder air, which might be caused by up-slope motion or cooling of the ground after sunset, may result in extensive fog.

In stable air as the warm air progresses up the slope with constantly falling temperature, clouds appear at increasing heights in the form of altostratus and cirrostratus. If the warm air is unstable, cumulonimbus clouds and altocumulus clouds will form and frequently produce thunderstorms. Finally, the air is forced up near the stratosphere, and in the freezing temperatures at that level the condensation appears as thin wisps of cirrus clouds. This up-slope movement is very gradual, rising about 1,000 feet every 20 miles. Thus cirrus clouds, forming at perhaps 25,000 feet, may appear as far as 500 miles in advance of the point on the ground which marks the position of the front.

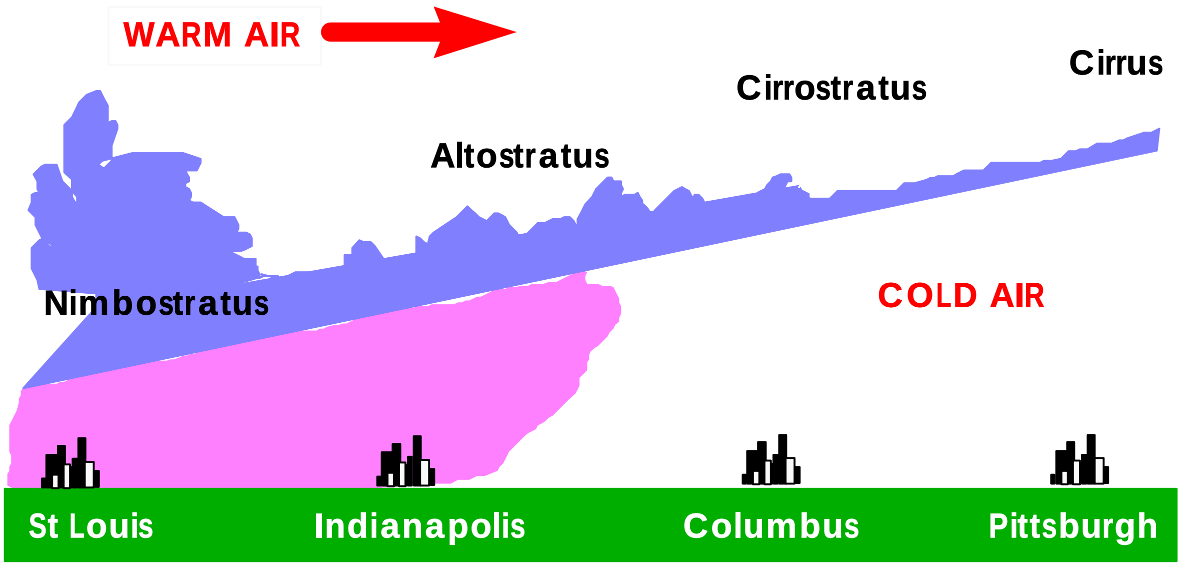
Warm fronts generally move at the rate of 10 to 25 miles an hour.

5.3.2 Flight toward an approaching warm front

Although no two fronts are exactly alike, a clearer understanding of the general weather pattern may be gained by looking at the conditions which might exist when a warm front is moving eastward from St. Louis, Mo.:

- In St. Louis the weather would be unpleasant, with drizzle and possibly fog.
- At Indianapolis, Ind., 200 miles in advance of the warm front, the sky would be overcast with nimbostratus clouds, and continuous rain.
- At Columbus, Ohio, 400 miles in advance, the sky would be overcast with predominantly stratus and altostratus clouds. A steady rain is likely.
- At Pittsburgh, Pa., 600 miles ahead of the front, there would probably be high cirrus and cirrostratus clouds.

If you flew from Pittsburgh towards St. Louis, ceiling and visibility would decrease steadily. Starting under bright skies with unlimited ceilings and visibilities, lowering stratus-type clouds and precipitation would be encountered as you approached Columbus. By the time you reached Indianapolis the ceilings would be too low for further flight, and precipitation may have reduced visibility to practically zero. Thus you would have to remain in Indianapolis until the warm



front passes, which might take a day or two.

On the trip from Pittsburgh to Indianapolis you would notice a gradual increase in temperature and a much faster increase in dew point, until the two coincided. Also, the atmospheric pressure would be gradually lessening because the warmer air aloft would have less weight than the colder air it was replacing. This condition illustrates the general principle that a falling barometer indicates the approach of stormy weather.

If you wanted to fly from St. Louis to Pittsburgh, it would be best to wait until the front had passed beyond Pittsburgh. This might take three or four days.

5.3.3 Cold Front

When the cold front moves forward it acts like a snow plow, sliding under the warmer air and forcing it aloft. This cools the warm air and forms clouds (cloud type depends upon whether the warm air is stable or unstable).

The slope of a cold front is much steeper than that of a warm front and its progress is generally more rapid -- usually from 20 to 35 miles per hour. In extreme cases, cold fronts have been known to move at 60 miles per hour. Cold fronts rush in almost unannounced, make a complete change in the weather within a period of a few hours, and moves on.

In these fast-moving fronts, friction retards the front near the ground and brings about a steeper frontal surface. This steep frontal surface results in a narrower band of weather concentrated along the forward edge of the front. If the warm air is stable, an overcast sky may occur for some distance ahead of the front, accompanied by general rain. If the warm air is unstable, scattered thunderstorms and showers may form. Altostratus clouds sometimes form slightly ahead of the front, bur these are seldom more than 100 miles in advance.

At times, an almost continuous line of thunderstorms may form along the front or ahead of it. These lines of thunderstorms (squall lines) contain some of the most turbulent weather experienced by pilots. Weather clears rapidly behind a fast-moving cold front, although gusty and turbulent surface winds and colder temperatures prevail.

This weather activity is more violent than that associated with warm fronts, and usually takes place directly at the front instead of occurring in advance of the front. In late afternoon during the warm season, however, squall lines frequently develop as much as 50 to 200 miles in advance of the actual cold front. Whereas warm front dangers are low ceilings and visibilities, cold front dangers are chiefly sudden storms, high and gusty winds, and turbulence.

5.3.4 Flight toward an approaching cold front

If a flight was made from Pittsburgh toward St. Louis when a cold front was approaching from St. Louis, weather conditions quite different from those associated with a warm front will be experienced. The sky in Pittsburgh would probably be somewhat overcast with the stratocumulus clouds typical of a warm air mass. The air would be smooth, with relatively low ceilings and visibility.

As the flight proceeded, these conditions would prevail until reaching Indianapolis. At this point it would be wise to check the position of the cold front. It would probably be about 75 miles west of Indianapolis. A pilot familiar with frontal systems would remain in Indianapolis until the front had passed -- a matter of a few hours -- and then continue to the destination under near perfect flying conditions.

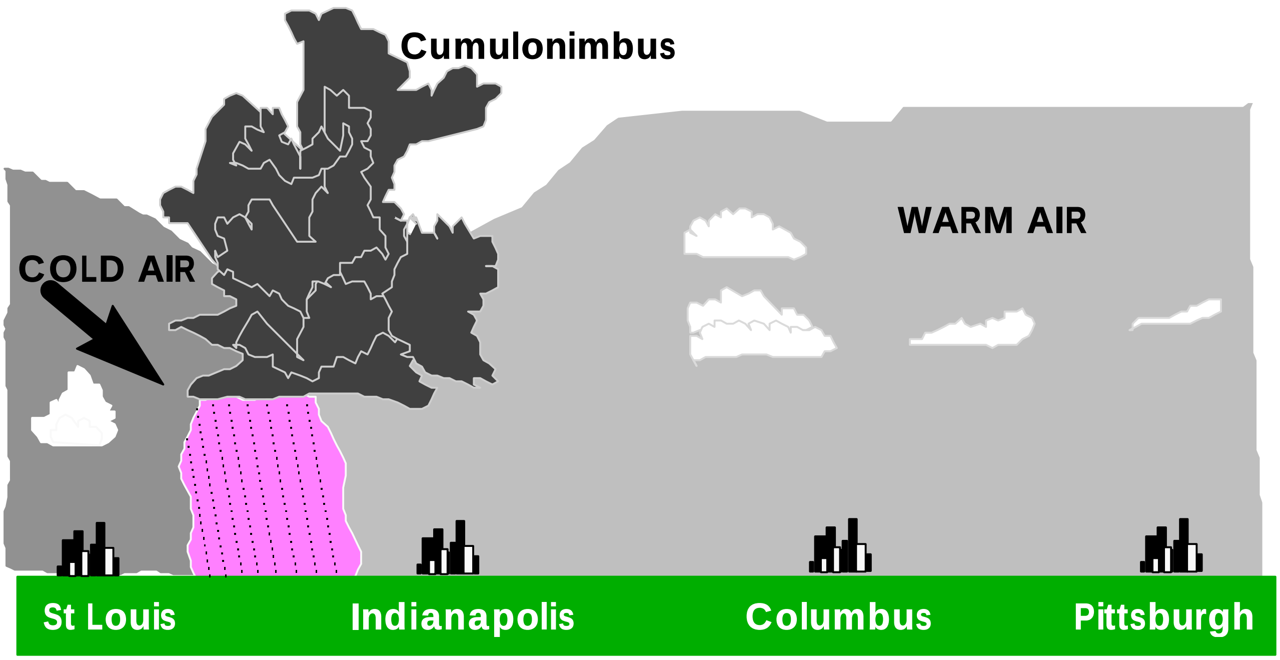
However, assume the pilot continued toward the approaching cold front. He would see a few altostratus clouds with a dark layer of nimbostratus lying low on the horizon, and perhaps cumulonimbus in the background. Two courses would now be open:

- Either turn around and outdistance the storm, or
- Make an immediate landing, which might be extremely dangerous because of gustiness and sudden wind shifts (wind shear).

If, however, the flight was continued, the pilot would be trapped in a line of squalls and cumulonimbus clouds. It is impossible (in a small plane) to fly above thunderstorms, and it is usually disastrous to try and fly beneath them. At low altitudes there are no safe passages through the squalls, and there is usually little chance of flying around them because they often extend in a line for 300 to 500 miles.

5.3.5 Occluded Front

One other form of front is the "exclusion" or "occluded front." This is a



condition in which an air mass is trapped between two colder air masses and forced aloft to higher and higher levels, until it finally spreads out and loses its identity. An occluded front appears on weather maps as shown in Figure 5-4.

Meteorologists subdivide occlusions into two types, but, so far as the pilot is concerned, the weather in any occlusion is a combination of warm front and cold front conditions. As the occlusion approaches, the usual warm front indications prevail -- lowering ceilings, lowering visibility, and precipitation. Generally, the warm front weather is then followed almost immediately by cold front weather, with its squalls, turbulence, and thunderstorms.

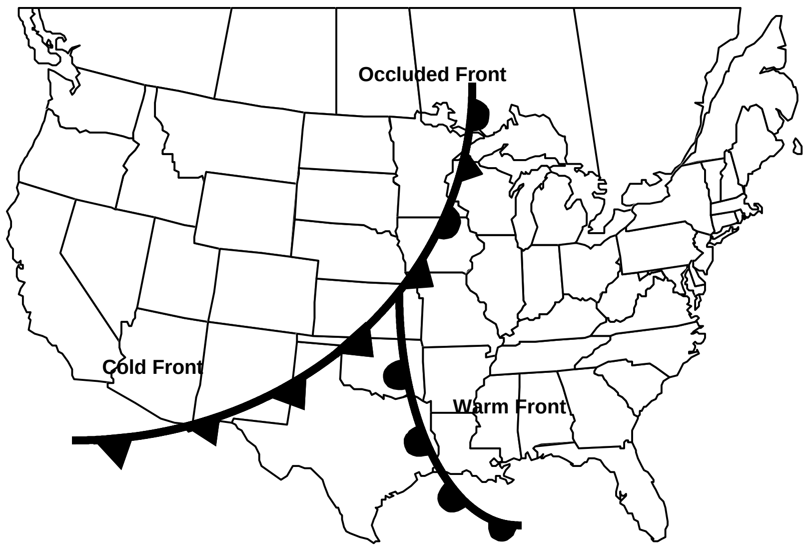


Figure 5-4

Reduced Visibility

According to FAA regulations, under almost all circumstances, flight using visual flight rules (VFR) can only be conducted with at least three miles of visibility. If more than one-half the sky is covered by clouds, the cloud bases must be no lower than 1,000 feet above the terrain. In addition, the VFR pilot must remain clear of all clouds.

One of the most common hazardous-weather problems is loss of visibility. This can happen suddenly or very insidiously, depriving the pilot of his ability to see and avoid other aircraft and reducing or depriving him altogether of his ability to control the aircraft, unless he has had training and is proficient in instrument flying. In reduced visibility, the crew's ability to see and avoid towers, power transmission lines, and other man-made obstacles is diminished (not to mention the problems it causes in finding your target).

Visibility is reduced by conditions such as clouds, rain, snow, fog, haze, smoke, blowing dust, sand, and snow. A similar condition called “white out” can occur where there has been snowfall.

In most regions of the country, fog and haze are the most common weather conditions that cause reduced visibility. Fog, especially dense fog, can pose a hazard to even the most sophisticated military or civilian aircraft. In thick fog, reduced visibility may make it extremely difficult, if not impossible, to see landing runways or areas. The crew should be alert for a potential problem with fog whenever the air is relatively still, the temperature and dew point are within several degrees, and the temperature is expected to drop further (e.g., around sunset or shortly after sunrise).

Haze, a fine, smoke-like dust, causes lack of transparency in the air. It’s most often caused when still air prevents normal atmospheric mixing. If the wind remains calm for several days, visibility will become progressively worse. This atmospheric condition is most common in heavily populated, industrialized areas of the country. It can also be present anywhere there is still air and a source of particles, like burning farm fields or thick forests that produce large quantities of pollen. It is especially noticeable in the early morning.

Frequently, as the sun warms the cool, hazy air and causes it to expand and rise, visibility at the surface will improve and appear acceptable. What initially appeared to be ample visibility can, after takeoff, become almost a complete obstruction to lateral or forward visibility several hundred feet above the surface. Downward visibility is satisfactory, but pilots may feel apprehensive about the loss of a visible horizon to help judge aircraft control, and about what might come out of the murk ahead. Visibility at this altitude may actually be more than the minimum three miles, yet the pilot may interpret this visual range as a wall just beyond the airplane's nose.

In summer, haze and smoke may extend upward more than 10,000 feet during the heat of the day. This presents a special hazard as it can hide rain showers or thunderstorms. When haze and smoke are present, the best action a flight crew can take to minimize this risk is to get a thorough weather briefing before flying and update the briefing during the flight.

Blowing dust is normally found in the relatively dry areas of the country, like the desert southwest. The condition develops when strong wind picks up small soil particles and air currents carry it upward into the atmosphere. These conditions can spread dust hundreds of miles and up to 15,000 feet. Depending upon wind speed and particle volume, visibility in dust storms may be reduced to very low levels. Blowing sand is much more localized than dust, occurring only when the wind is strong enough to lift loose sand. Since sand particles are much heavier than dust, sand is seldom lifted more than 50 feet above the surface. Still, the condition eliminates the effectiveness of visual searches, and in many cases can prohibit an aircraft from taking off or landing.

Strong surface winds can also cause blowing snow. Blowing snow is more frequent in areas where dry, powdery snow is found. For the aviator, blowing snow can cause the same problems of reduced visibility. Like dust, it can reach thousands of feet above the surface.

Snow can cause another visibility problem, known as “white out.” This condition can occur anywhere there is snow-covered ground, but is most common in arctic regions. It's not a physical obstruction to visibility like earlier examples, but an optical phenomenon. White out requires a snow-covered surface and low-level clouds of uniform thickness. At low sun angles, light rays are diffused as they penetrate the cloud layer causing them to strike the snow-covered surface at many angles and eliminating all shadows. The net effects are loss of a visible horizon and loss of depth perception, each of which can make low-level flight and landings difficult and hazardous.

5.5 Turbulence

Turbulence is irregular atmospheric motion or disturbed wind flow, and can be attributed to a number of causes. Under almost all circumstances, small amounts of normal atmospheric turbulence can be expected and it usually poses few problems. Previous sections covered wake turbulence and convective activity as causes of turbulence. Convective activity was covered in the context of thunderstorm development, but any phenomenon that causes air to be lifted up -- even a hot asphalt parking lot -- can cause turbulence. Other causes include obstructions to wind flow and wind shear.

Just as a tree branch dangling into a stream creates continuous ripples or waves of turbulence in the water's surface, obstructions to the wind can create turbulence in the air. This type of turbulence usually occurs close to the ground, although it may reach upward several thousand feet, depending upon wind velocity and the nature of the obstruction. In an extreme case, when winds blow against a mountainside the mountain deflects the wind upward, creating a relatively smooth updraft. Once the wind passes the summit, it tumbles down the leeward or downwind side, forming a churning, turbulent down draft of potentially violent intensity. The churning turbulence can then develop into *mountain waves* that may continue many miles from the mountain ridge. Mountain waves may be a factor when surface winds are as little as 15 knots.

Turbulence can be inconsequential, mildly distracting, nauseating, or destructive depending on its intensity. Turbulence can often be avoided by changing altitudes.

Aircraft manufacturers publish *maneuvering speeds* in the operating handbooks. If the maneuvering airspeed of an aircraft is exceeded in turbulent air, structural damage could occur.

5.6 Wind, windshear and mountain wave

Windshear is best described as a change in wind direction and/or speed within a very short distance. Under certain conditions, the atmosphere is capable of producing some dramatic shears very close to the ground; for example, wind directional changes of 180 degrees and speed changes of 50 knots or more within 200 feet of the ground have been observed. This, however, is not something encountered every day. In fact it is unusual, which makes it more of a problem. It has been thought that wind can not affect an aircraft once it is flying except for drift and groundspeed. This is true with steady winds or winds that change gradually. It isn't true, however, if the wind changes faster than the aircraft mass can be accelerated or decelerated.

The most prominent meteorological phenomena that cause significant low-level windshear problems are thunderstorms and certain frontal systems at or near an airport.

Basically, there are two potentially hazardous shear situations: 1) a tailwind may shear to either a calm or headwind component. Initially the airspeed increases, the aircraft pitches up, and the altitude increases. 2) a headwind may shear to a calm or tailwind component. Initially the airspeed decreases, the aircraft pitches down, and the altitude decreases. Aircraft speed, aerodynamic characteristics, power/weight ratio, power plant response time, pilot reactions and other factors have a bearing on wind shear effects. It is important, however, to remember that shear can cause problems for any aircraft and any pilot.

There are two atmospheric conditions that cause the type of low-level wind shear discussed herein: thunderstorms and fronts.

The winds around a thunderstorm are complex. Windshear can be found on all sides of a cell. The wind shift line or gust front associated with thunderstorms can precede the actual storm by up to 15 nautical miles. Consequently, if a thunderstorm is near an airport of intended landing or takeoff, low-level wind shear hazards may exist.

While the direction of the winds above and below a front can be accurately determined, existing procedures do not provide precise and current measurements of the height of the front above an airport. The following is a method of determining the approximate height of the front, with the consideration that wind shear is most critical when it occurs close to the ground.

- A cold front windshear occurs just after the front passes the airport and for a short period thereafter. If the front is moving 30 knots or more, the frontal surface will usually be 5,000 ft. above the airport about 3 hours after the passage.
- With a warm front, the most critical period is before the front passes the airport. Warm front shear may exist below 5,000 ft. for approximately 6 hours; the problem ceases to exist after the front passes the airport. *Data compiled on windshear indicate that the amount of shear in warm fronts is much greater than that found in cold fronts*.
- Turbulence may or may not exist in windshear conditions. If the surface wind under the front is strong and gusty, there will be some turbulence associated with windshear.

The pilot should be alert to the possibilities of low-level windshear any time the conditions discussed are present.

5.7 Thunderstorms

A thunderstorm is any storm accompanied by thunder and lighting. It usually includes some form of precipitation, and can cause trouble for aircraft in many forms: turbulence, icing, poor visibility, hail, wind shear, microbursts, lightning, and, in severe cases, tornadoes.

Individual thunderstorms may often be very local in nature, although they often form along weather fronts and appear to march across the land in long lines. This is the situation when weather forecasters announce that a line of thunderstorms is approaching, and thunderstorm warnings go into effect. Individual thunderstorms are rarely larger than 10 miles in diameter, and typically develop, mature, and dissipate within an hour and a half at the most. Each is produced by the growth of a puffy cumulus cloud into a cumulonimbus cloud. The severe elements of a thunderstorm result from the vertical air movement, or convective activity, within the storm.

Thunderstorms may be studied by dividing them into three separate growth stages: the (cumulus) building stage, the mature stage, and the dissipating stage. Figure 5-5 demonstrates the physical appearances of each stage of the developing storm.

Most cumulus clouds do not become thunderstorms, but all thunderstorms are born as cumulus clouds. The main feature of this first stage of thunderstorm development is its updraft, a large air current flowing upward from the ground through the chimney-like cloud. The draft can reach speeds of several thousand feet per minute, and continue to an altitude of 40,000 feet or more. During this period, small water droplets grow into raindrops as the cloud builds upward to become a cumulonimbus cloud.

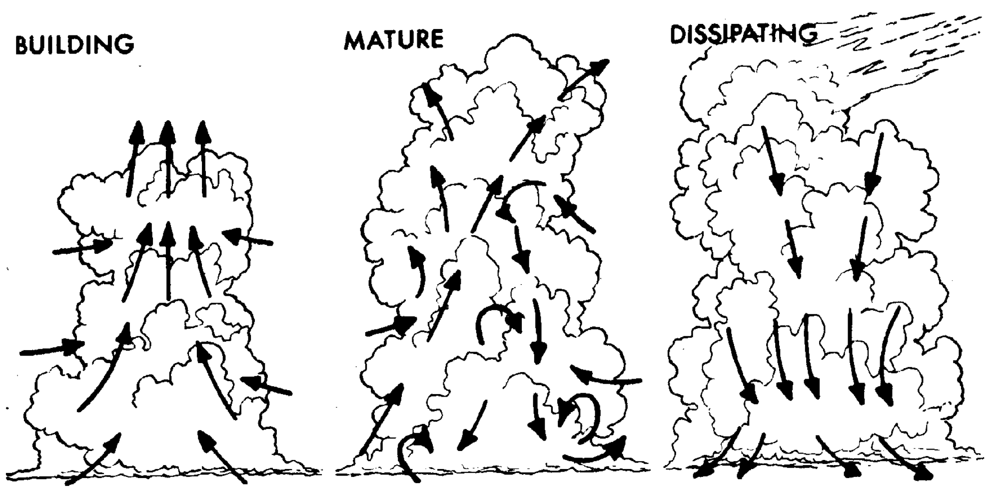


Figure 5-5

Precipitation at the earth's surface marks the mature stage of a thunderstorm. The raindrops (or ice particles) have now become so large and heavy that the updraft can no longer support them, and they begin to fall. As they fall, the raindrops drag air with them, causing the characteristic strong down draft of mature thunderstorms. These down drafts spread out horizontally when they reach the surface, producing strong, gusty winds, wind shear, sharp drops in temperature (because the air was chilled at high altitudes) and a sharp rise in pressure.

The mature stage of the thunderstorm is when associated hazards are most likely to reach maximum intensity. Microbursts, extremely intense down drafts, can occur during this mature phase of development. Downward wind velocities in microbursts *may reach 6,000 feet per minute*, and even powerful jet aircraft may have insufficient power to recover prior to ground impact.

As down drafts continue to spread the updrafts weaken, and the entire thunderstorm eventually becomes an area of down drafts. This characterizes the dissipating stage of the thunderstorm. During this stage, the cloud develops the characteristic anvil shape at the top and may take on a stratiform or layered appearance at the bottom. Usually this stage is the longest of the three stages of a thunderstorm's life.

No thunderstorm should ever be taken lightly. During the cumulus stage, vertical growth occurs so quickly that climbing over the developing thunderstorm is not possible. Flight beneath a thunderstorm, especially in the mature stage, is considered very foolish, due to the violent down drafts and turbulence beneath them. Flight around them may be a possibility, but can still be dangerous. Even though the aircraft may be in clear air, it may encounter hail, lightning, or turbulence a significant distance from the storm's core. Thunderstorms should be avoided by at least 20 miles laterally. The safest alternative, when confronted by thunderstorms, is to land, hanger or tie-down the aircraft, and wait for the storms to dissipate or move on.

1.1.1.1.1.5 Chapter

6

6. High Altitude and Terrain Considerations

6.1 Measurement of atmospheric pressure

A barometer is generally used to measure the height of a column of mercury in a glass tube. It is sealed at one end and calibrated in inches. An increase in pressure forces the mercury higher in the tube; a decrease allows some of the mercury to drain out, reducing the height of the column. In this way, changes of pressure are registered in inches of mercury. The standard sea-level pressure expressed in these terms is 29.92 inches at a standard temperature of 15 degrees C. (59 degrees F.).

The mercury barometer is cumbersome to move and difficult to read. A more compact, easily read and mobile barometer is the aneroid, although it is not as accurate as the mercurial. The aneroid barometer is a partially evacuated cell that is sensitive to pressure changes. The cell is linked to an indicator that moves across a scale that is graduated in pressure units. A common aneroid barometer is the altimeter.

If all weather stations were at sea level, the barometer readings would give a correct record of the distribution of atmospheric pressure at a common level. To achieve a common level, each station translates its barometer reading into terms of mean sea level (MSL) pressure. A change of 1,000 feet of elevation makes a change of about 1 inch on the barometer reading. Thus, if a station located 5,000 feet above sea level found the mercury to be 25 inches high in the barometer tube, it would translate and report this reading as 30 inches.

Since the rate of decrease in atmospheric pressure is fairly constant in the lower layers of the atmosphere, the approximate altitude can be determined by finding the difference between pressure at sea level and pressure at the given atmospheric level. In fact, the aircraft altimeter is an aneroid barometer with its scale in units of altitude instead of pressure.

It can be concluded that atmospheric pressure decreases as altitude increases. It can also be stated that pressure at a given point is a measure of the weight of the column of air above that point. As altitude increases, pressure diminishes as the weight of the air column decreases. This decrease in pressure (increase in density altitude) has a pronounced effect on flight.

6.2 Aircraft performance limitations

The air in which all aircraft operate is a dynamic and constantly changing environment. Changes within the air mass can have a profound effect on performance of aircraft engines, wings, propellers, and the individuals who operate aircraft. If all missions were conducted on cool, low humidity days in South Florida or along the Gulf coast, there would be no concern with air density and its implications on flight safety. Obviously, this isn't the case. In fact, these conditions have often been primary factors in aircraft accidents, and may result in loss of the search aircraft unless you pay careful attention. This section will cover the forces at work and identify strategies for dealing with them.

The average pressure exerted by the atmosphere is approximately 15 pounds per square inch at sea level. This means that a column of air 1 inch square extending from sea level to the top of the atmosphere would weigh about 15 pounds. However, the actual pressure at a given place and time depends upon several factors, including altitude, temperature, and density of the air. These conditions very definitely affect flight.

The most noticeable effect of the decrease in pressure (increase in density altitude) due to an altitude increase becomes evident in takeoffs, rates of climb, and landings. An airplane that requires a 1,000-foot run for takeoff at a sea-level airport will require a run almost twice as long to take off at an airport which is 5,000 feet above sea level.

The purpose of the takeoff run is to gain enough speed to generate lift from the passage of air over the wings. If the air is thin, more speed is required to obtain enough lift for takeoff -- hence a longer ground run. It is also true that the engine is less efficient in thin air, and the thrust of the propeller is less effective. The rate of climb is also slower at the higher elevation, requiring a greater distance to gain the altitude to clear any obstructions. In landing, the difference is not so noticeable except that the plane has greater groundspeed when it touches the ground.

Three factors affect the density of the air mass: humidity, temperature, and altitude. Humidity has a smaller effect on air density and aircraft performance than temperature or altitude, and it's nearly impossible to precisely identify the effect. Most engine and airplane manufacturers don't provide performance figures or test data to help the crew determine the effect of humidity on aircraft performance. Nevertheless, observers are expected to have an understanding of the effect humidity has on air density.

6.2.1 Humidity

The air mass is a blend of gases including oxygen, carbon dioxide, nitrogen (the most plentiful), gaseous water or water vapor, and other trace gases. A molecule of gaseous water *weighs* only 64% of the weight of a molecule of free nitrogen. As humidity increases (or more molecules of water vapor are present), molecules of nitrogen and other gases are displaced. Humid air weighs <u>less</u> than an equivalent amount of dry air.

Because the humid blend of gases is less dense, propellers and tail rotors generate less thrust. Wings, main rotors, and control surfaces develop less lift. Further, because oxygen molecules have been displaced, fewer molecules are available for fuel mixing. Engines don't develop as much power as they might in dryer air.

6.2.2 Temperature

The temperature of the air has a greater effect on air density than humidity. As the temperature of any unconfined gas increases, its molecules move farther apart. The gas now weighs less than the same volume of gas at a cooler temperature. The effects of this loss of air density are the same as the effects of humidity. Unlike humidity, these effects are easily determined by the pilot by using the operating handbook.

Air Temperature °F	Horsepower	Landing Distance
34	113	1295 feet
52	110	1330 feet
70	107	1360 feet
88	104	1390 feet

Compiled from aircraft flight manual. Presented here for training purposes only.

Figure 6-1

As shown in Figure 6-1, a light aircraft engine operating at a constant altitude and constant power setting *loses* 3 horsepower for each 18-degree increase in air temperature. The same plane's required landing distance *increases* by about 30 feet for each 18-degree increase. Performance loss by other manufacturers' engines and airplanes will of course vary from those presented here, but the effect is the same.

6.2.3 Altitude

Altitude can be expressed in terms of the airplane's height above ground level (AGL) or its height above mean sea level (MSL). This section will cover altitude in terms of the plane's height above sea level, the *sum* of the airplane's height above the terrain *plus* the terrain elevation above sea level.

Elevation	Temperature	Engine Horsepower	Rate of Climb	Take Off Distance
Sea Level	59°F	160	700 feet/minute	1,627 feet
	85°F	-	-	1,810 feet
7,000'	59°F	140	338 feet/ minute	3,627 feet
	85°F	-	-	4,200 feet

Compiled from aircraft flight manual. Presented here for training purposes only.

Figure 6-2

Unlike water, which cannot be compressed under pressure, the gases in the atmosphere *can* be compressed by pressure. Thus, the molecules are more dense near the earth's surface. At sea level, air pushes downward and laterally with an approximate force of 14.7 pounds per square inch. The higher one goes above sea level, the less the pressure pushing downward. This decrease in density that occurs as altitude increases has the same effect on aircraft and engine performance as humidity and heat, but of significantly *greater* magnitude.

As another example, at an airport near sea level like Key West, Florida, an aircraft engine develops 160 horsepower at maximum power. The same engine at Durango, Colorado, (elevation 6,685 feet above sea level) only develops approximately 140 horsepower at maximum power. The plane's rate of climb is cut by *one half*, and at maximum takeoff weight the distance required for takeoff is *doubled* -- due only to the difference in air densities at the two elevations. This additional loss of performance is shown in Figure 6-2.

The <u>combined</u> effects of temperature and altitude may be very significant. By adding the search altitude to the terrain elevation of the area to be searched, you can determine the altitude above sea level at which you will fly the mission. Then, figure the *density altitude* by applying temperature to that altitude. Figure 6-3, a density altitude table, is one means the crew may use to determine density altitude.

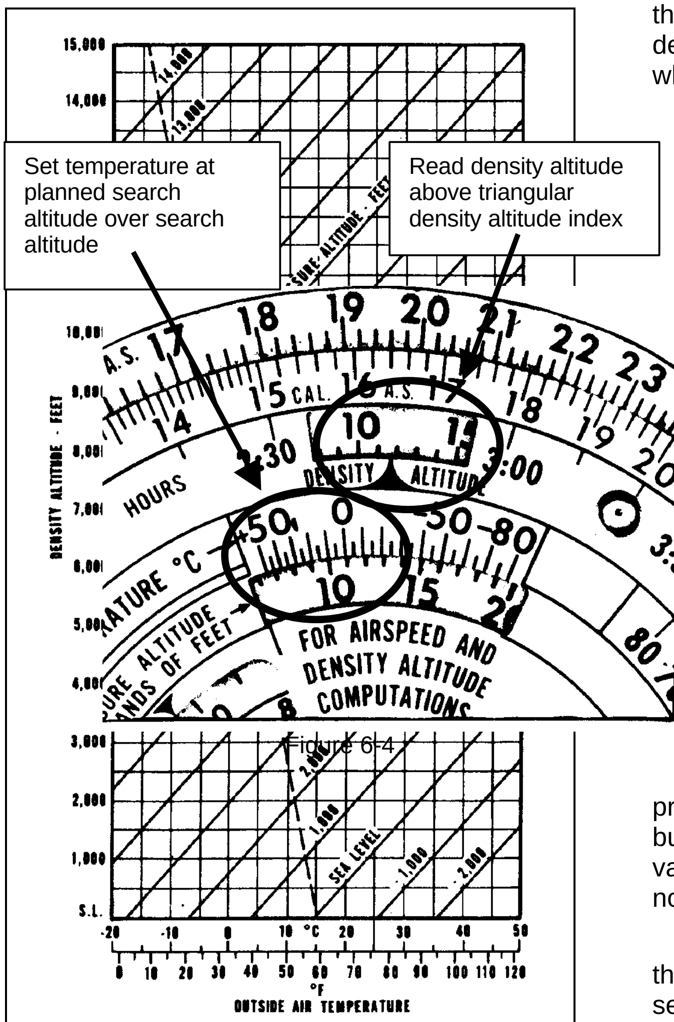


Figure 6-4

Figure 6-3

It's important to understand that density altitude helps the pilot determine the expected loss of engine and airplane performance from higher altitude and temperature. It’s *not* a number you will actually read on the aircraft altimeter. As indicated earlier, humidity is not considered in this determination.

Use density altitude and the operating handbook to determine takeoff, climb, and landing performance. Each airplane manufacturer has data that is specific to each type and model of airplane. The data is usually presented in easy-to-use tables or graphs, but the various manufacturers use a variety of methods. Specific methods will not be addressed in this text.

The preceding sections have covered the affects of temperature and altitude separately. However, these factors don’t occur separately, and the affects of increased temperature *and* altitude are very important. From the previous example, the Key West engine develops 160 horsepower and the aircraft requires a 1,627-foot takeoff distance on a 59° day. As air temperature increases to 85° that takeoff distance increases to 1,810 feet. The Durango engine develops 140 horsepower and requires 3,627 feet for take-off at 59°. As the Durango temperature increases to 85° takeoff distance increases to over 4,200 feet. It's still the same airplane, same engine, and same weight, only the effects of high air temperature and high elevation are becoming critical. Imagine the "impact" of these factors if the Durango runway were only 3,800 feet long!

Away from the airport, the effect of high-density altitude still has a great affect on aircraft performance. The manufacturer of each CAP-operated airplane has published in the operating handbook a “service ceiling” for that airplane. The service ceiling is that altitude at which the airplane can no longer maintain at least a 100-foot per minute climb rate. For many CAP single-engine airplanes, having engines that are neither super-charged nor turbo-charged, this ceiling is near 13,000 feet. While searches would not normally be conducted at such an altitude, the effect of temperature and air density can bring the service ceiling *down*, and it may become a factor at altitudes commonly used by CAP aircraft.

Imagine a hypothetical July search based at Truth or Consequences, New Mexico, where the airport elevation is 4,850 feet above sea level. Air temperature is reported at 84°F or 29°C. The terrain in the search area rises about 3,000 feet above the airport, and the assigned search altitude is 1,000 feet above the terrain. The altitude you would expect to read on the airplane's altimeter could be determined as follows:

4,850 feet - airport elevation above sea level

+3,000 feet - height of terrain to be searched

+1,000 feet - search altitude

8,850 feet - search altitude above sea level

You can use either a density altitude table (like the one in Figure 6-4) or the slide rule “face” of the whiz wheel to determine the density altitude. Because air temperature decreases about 2°C for each 1,000 feet of altitude, air temperature at 9,000 feet will be about 21°C. Enter the table at the bottom at 21°C, and move up until you intersect the 9,000 foot search altitude diagonal line. Then look across to the left and find the density altitude of about 11,500 feet.

On the flight computer, set +21° on the temperature scale in the temperature/altitude “window” over the 9,000-foot search altitude, as shown in Figure 6-4. Read the density altitude above the triangular density-altitude index mark.

Again, the density altitude is about 11,500 feet. This is very close to the density altitude-equivalent service ceiling. The climb rate will likely be only slightly better than 100 feet per minute.

A climb rate of 100 feet per minute at 120 knots gives a no-wind climb angle or gradient of approximately 50 feet per mile, substantially less than that required to climb over rapidly rising, mountainous terrain.

Compared to turns at low altitude, turns in high-density altitudes have larger turn radiuses and slower turn rates. The airplane cannot reverse course so quickly and a 180° turn requires more room. Steep-banked, tight turns should also be avoided because the aircraft may have insufficient power or speed (or both) to complete the turn without losing altitude.

Crews must be constantly careful that the search never takes them over terrain that rises faster than the airplane can climb. Narrow valleys or canyons that have rising floors must be avoided, unless the aircraft can be flown from the end of higher elevation to the lower end, or the pilot is *certain* that the aircraft can climb faster than the terrain rises. Careful chart study by the crew prior to flight will help identify this dangerous terrain.

Density altitude's effect on twin-engine aircraft can be catastrophic in the event of a power loss by one engine. Most CAP-operated “twins” would not be able to climb at all and may not be able to maintain level flight under such circumstances. The pilot then flies an airspeed that allows a minimum rate of descent and starts looking for a suitable place to land. Hopefully, a runway will be nearby.

6.2.4 Strategies

The search and rescue team can make a number of decisions that can help minimize effects of high density altitude and maximize flight safety. If aircraft having turbo-charged or super-charged engines are available, the incident commander may assign their crews that part of the search over the high terrain. Supercharging or turbocharging regains some of the engine performance lost with the decrease in air density, but cannot improve upon that lost from the wings or propeller. If no supercharged or turbo-charged aircraft are available, then the ones with the larger engines should be assigned to search the high terrain (e.g., C-182 instead of a C-172).

Incident commanders may schedule flights to avoid searching areas of high elevation during the hottest times of the day. This is a tradeoff though, in that the best sun angles for good search visibility often coincide with the hot times of the day. The IC/MC may also elect to limit crew size to minimize airplane total weight. Instead of dispatching a four-seat aircraft with a pilot, observer, and two scanners aboard, she may elect to send a pilot, observer and single scanner only. Again, this represents a tradeoff, where some search capability is sacrificed for a higher margin of safety.

The pilot may decide to takeoff on a mission with only the fuel required for that mission and the required reserve, rather than departing with full fuel tanks. Each crewmember can help by leaving all *nonessential* equipment or personal possessions behind. In high density altitudes, airplane performance can be improved significantly by simply leaving nonessential, excess weight behind.

To help remember these conditions and their effects, an observer should remember the four H's: <u>H</u>igher <u>H</u>umidity, <u>H</u>eat, or <u>H</u>eight all result in reduced aircraft performance. Available engine power is reduced, climb capability is reduced, and takeoff and landing distances are increased.

6.3 Effects on crewmember performance

The factors previously discussed can have similarly degrading effects on the ability of crewmembers to perform their job tasks. As air temperature increases, so does each crewmember's susceptibility to nausea, airsickness, and dehydration. As humidity increases with temperature, the body's ability to regulate its own temperature by perspiration can be negatively affected, beginning the initial symptoms of heat exhaustion.

When operating in high temperatures, crewmembers should dress accordingly and make every effort to drink plenty of water, juice, or caffeine-free soft drinks prior to, during, and after each mission to help prevent dehydration.

Heat related problems can be mitigated by increasing the flow of outside air through the aircraft interior. If sufficient airflow cannot be gained, cooler air can usually be located by climbing the aircraft to a higher altitude; however, this may be inconsistent with assigned search altitudes or beyond the performance capability of the aircraft.

Altitude has several affects on human performance including ear block, sinus block and hypoxia. Observers should be aware of these factors in their own performance and also watch for them to occur in other crewmembers.

6.3.1 Ear block

As aircraft cabin pressure decreases during ascent, the expanding air in the middle ear pushes the eustachian tube open and, by escaping down to the nasal passages, equalizes with the cabin pressure. However, during descent the crewmembers must periodically open the eustachian tube to equalize pressure. This can be accomplished by swallowing, yawning, tensing muscles in the throat or, if these do not work, by the combination of closing the mouth, pinching the nose closed and attempting to blow through the nostrils (valsalva maneuver).

Either an upper respiratory infection, such as a cold or sore throat, or a nasal allergic condition can produce enough congestion around the eustachian tube to make equalization difficult. Consequently, the difference in pressure between the middle ear and aircraft cabin can build up to a level that will hold the eustachian tube closed, making equalization difficult if not impossible. This problem is commonly referred to as an "ear block."

An ear block produces severe ear pain and loss of hearing that can last from several hours to several days. Rupture of the eardrum can occur in flight or after landing. Fluid can accumulate in the middle ear and become infected. An ear block is prevented by not flying with an upper respiratory infection or nasal allergic condition. Adequate protection is usually not provided by decongestant sprays or drops to reduce congestion around the eustachian tube. Oral decongestants have side effects that can significantly impair pilot performance. If an ear block does not clear shortly after landing, a physician should be consulted.

6.3.2 Sinus block

During ascent and descent, air pressure in the sinuses equalizes with the aircraft cabin pressure through small openings that connect the sinuses to the nasal passages. Either an upper respiratory infection or a nasal allergic condition can produce enough congestion around the openings to slow equalization and, as the difference in pressure between the sinus and cabin increases, eventually plug the opening. This "sinus block" occurs most frequently during descent.

A sinus block can occur in the frontal sinuses, located above each eyebrow, or in the maxillary sinuses, located in each upper cheek. It will usually produce excruciating pain over the sinus area. A maxillary sinus block can also make the upper teeth ache. Bloody mucus may discharge from the nasal passages.

A sinus block is prevented by not flying with an upper respiratory infection or nasal allergic condition. Adequate protection is usually not provided by decongestant sprays or drops to reduce congestion around the sinus openings. Oral decongestants have side effects that can impair pilot performance. If a sinus block does not clear shortly after landing, a physician should be consulted.

6.3.3 Hypoxia

Hypoxia is a state of oxygen deficiency in the body sufficient to impair functions of the brain and other organs. Hypoxia from exposure to altitude is due only to the reduced barometric pressures encountered at altitude, as the concentration of oxygen in the atmosphere remains about 21 percent from the ground up to space.

Although deterioration in night vision occurs at a cabin pressure altitudes as low as 5,000 feet, other significant effects of altitude hypoxia usually do not occur in the normal healthy pilot below 12,000 feet. From 12,000 to 15,000 feet of altitude, judgment, memory, alertness, coordination and ability to make calculations are impaired, and headache, drowsiness, dizziness and either a sense of well being (euphoria) or belligerence may occur. In fact, pilot performance can seriously deteriorate within 15 minutes at 15,000 feet.

At cabin pressure altitudes above 15,000 feet, the periphery of the visual field grays out to a point where only central vision remains (tunnel vision). A blue coloration (cyanosis) of the fingernails and lips develops. The ability to take corrective and protective action is lost in 20 to 30 minutes at 18,000 feet and 5 to 12 minutes at 20,000 feet, followed soon thereafter by unconsciousness.

The altitude at which significant effects of hypoxia occur can be lowered by a number of factors. Carbon monoxide, inhaled in smoking or from exhaust fumes, lowers hemoglobin (anemia). Certain medications can reduce the oxygen-carrying capacity of the blood to the degree that the amount of oxygen provided to body tissues will already be equivalent to the oxygen provided to the tissues when exposed to a cabin pressure altitude of several thousand feet. Small amounts of alcohol and low doses of certain drugs, such as antihistamines, tranquilizers, sedatives and analgesics can, through their depressant actions, render the brain much more susceptible to hypoxia. Extreme heat and cold, fever and anxiety increase the body's demand for oxygen, and hence its susceptibility to hypoxia.

Hypoxia is prevented by avoiding factors that reduce tolerance to altitude, by enriching the inspired air with oxygen from an appropriate oxygen system and by maintaining a comfortable, safe cabin pressure altitude. For optimum protection, pilots are encouraged to use supplemental oxygen above 10,000 feet during the day and above 5,000 at night. The Federal Aviation Regulations require that the minimum flight crew be provided with and use supplemental oxygen after 30 minutes of exposure to cabin pressure altitudes between 12,500 and 14,000 feet, and immediately on exposure to cabin pressure altitudes above 14,000 feet. Every occupant of the aircraft must be provided with supplement oxygen at cabin pressure altitudes above 15,000 feet.

6.4 Mountainous terrain

When flying in mountainous areas it is recommended that flights be planned for early morning or late afternoon, because heavy turbulence is often encountered in the afternoon, especially during summer. In addition, flying during the coolest part of the day reduces density altitude. Attempt to fly with as little weight as possible, but don't sacrifice fuel; in the event of adverse weather, the additional reserve could be a lifesaver.

Study sectionals for altitudes required over the route and for obvious checkpoints. Prominent peaks make excellent checkpoints, but rivers and passes also make good checkpoints. Be aware that mountain ranges have many peaks, some of which may look the same to the untrained eye; continually crosscheck your position with other landmarks and radio aids if possible. Also, the minimum altitude at which many radio aids are usable is higher in the mountains. For this reason low-frequency navigation, such as ADF, LORAN, or GPS, tend to work best in the mountains.

A weather check is essential for mountain flying. Ask specifically about winds aloft even when the weather is good. Expect winds above 10,000 feet to be westerlies in the mountain states. If winds aloft at your proposed altitude are above 30 knots, do not fly. Winds will be of much greater velocity in passes, and it will be more turbulent as well. Do not fly closer than necessary to terrain such as cliffs or rugged areas. Dangerous turbulence can be expected, especially when there are high winds.

1.1.1.1.1.6 Chapter

7

7. Navigation and Position Determination

Navigation is the process of continuously determining your position so you can get from one place to another. By correctly using various navigational techniques, you can efficiently proceed from one point to the next while keeping off-course maneuvering, elapsed time, and fuel consumption to a minimum. Navigation and position determination is critical to the CAP mission. It doesn't do much good to find your search objective if you don't know where you are when you do. This chapter will cover the basic tools of navigation, navigational techniques, and the use of navigational aids (navaids) and instruments.

7.1 Navigation Terms

In order to effectively communicate with the pilot and ground teams, the mission observer must have a clear understanding of various terms that are used frequently when flying aboard CAP aircraft. These are not peculiar to search and rescue, but are used by all civilian and military aviators.

*Course - T*he planned or actual path of the aircraft over the ground. The course can be either *true course* or *magnetic course* depending upon whether it is measured by referencing true north or magnetic north. The magnetic north pole is *not* located at the true north pole on the actual axis of rotation, so there is usually a difference between true course and magnetic course.

Pilots use meridians of longitude to measure a true course on a map, and all of these meridians point to the true north pole. However the aircraft compass can only point at the magnetic north pole. Once you measure true course on the chart, you must apply *magnetic variation* to the true course to determine the magnetic direction you must fly in order to follow the true course. East magnetic variation is subtracted from measured true courses and west variation is added.

You can find magnetic variation factors in several places, and you will learn more about this in the section concerning charts. Magnetic variation factors also take into account abnormalities in the earth's magnetic field due to the uneven distribution of iron ore and other minerals.

Heading - The direction the aircraft is physically pointed. Airplanes don't always fly exactly in the direction they're pointed due to the effect of the wind. True headings are based on the true north pole, and magnetic headings are based on the magnetic north pole. Most airplane compasses can only reference magnetic north without resorting to advanced techniques or equipment, so headings are almost always magnetic.

Drift, or Drift Effect - The effect the wind has on an aircraft. The air mass an aircraft flies through rarely stands still. If you try to cross a river in a boat by pointing the bow straight across the river and maintaining that heading all the way across, you will impact the river bank downstream of your initial aim point due to the effect of the river current. In an aircraft, any wind that is not from directly in the front or rear of the aircraft has a similar affect.

Drift Correction - A number of degrees added to or subtracted from the aircraft heading intended to negate drift or drift effect. In the rowboat example, if you had aimed at a point upstream of the intended destination, you would have crossed in a straighter line. The <u>angle</u> between the intended impact point and the upstream aim point is analogous to drift correction.

Nautical mile - Distances in air navigation are usually measured in *nautical miles,* not statute miles. A nautical mile is about 6076 feet (sometimes rounded to 6080 ft.), compared to 5280 feet for the statute mile. Most experienced aviators simply refer to a nautical mile as a mile. Observers should remain aware of this difference when communicating with ground search teams because most ground or surface distances are measured using statute miles or kilometers. To convert nautical miles into statute miles, multiply nautical miles by 1.15. To find kilometers, multiply nautical miles by 1.85. Also, one nautical mile is equal to one minute of latitude measured along any meridian of longitude. This provides a convenient scale for measuring distances on any chart. Nautical miles are abbreviated "nm".

Knots - The number of nautical miles flown in one hour. Almost all airspeed indicators measure speed in terms of knots, not miles per hour. At one hundred knots an aircraft would fly one hundred nautical miles in one hour in a no wind condition. Some aircraft have airspeed indicators that measure speed in statute miles per hour, and the observer should be alert to this when planning. Knots can be used to measure both *airspeed* and *ground speed*. The air mass rarely stands still, and any headwind or tailwind will result in a difference between the aircraft's airspeed and ground speed. If you fly eastward at 100 knots airspeed, with the wind blowing from the west at 15 knots, your speed over the ground would be 115 knots. If you fly westbound into the wind, your speed over the ground drops to 85 knots. The abbreviation for knots is "kts".

7.2 Latitude and longitude

A system using imaginary reference lines has been developed to locate positions on the earth. These lines are known as parallels of latitude and meridians of longitude. The numbers representing a position in terms of latitude and longitude are known as the coordinates of that position. Refer to Figure 7-1.

You must have a thorough understanding of this coordinate system. It is used on all of our missions and it is the basis for the aircraft's Global Positioning System (GPS) unit, which is our primary means of navigation and position determination.

7.2.1 Latitude

The equator is a great circle midway between the poles. Its plane is perpendicular to a line connecting the poles. Parallel with the equator are lines of latitude. Each of these parallel lines is a small circle, and each has a definitive location. The location of the latitude is determined by figuring the angle at the center of the earth between the latitude and the equator.

The equator is latitude 0 degrees, and the poles are located at 90 degrees latitude. Since there are two latitudes with the same number (e.g., two 45-degree or two 30-

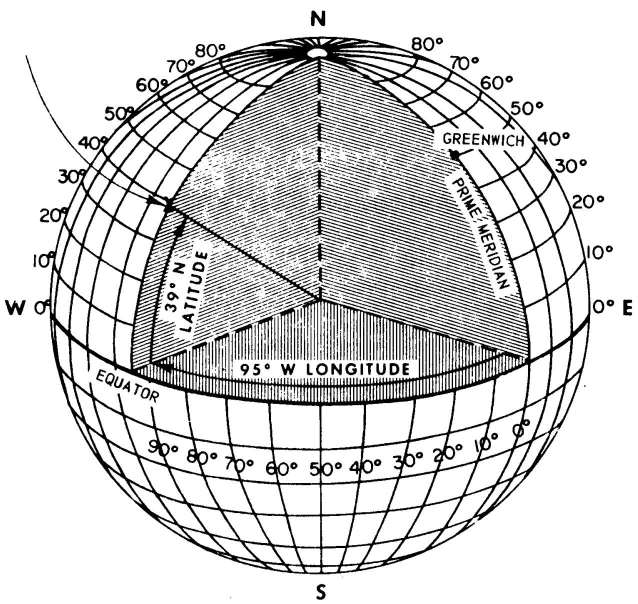


Figure 7-1

degree latitudes), the letter designators N and S are used to show which latitude is meant. The North Pole is 90 degrees north of the equator and the South Pole is 90 degrees south. Thus the areas between the poles and the equator are known as the northern and southern hemispheres.

7.2.2 Longitude

We have seen how the north-south measurement of positions is figured. With only latitude, it is still impossible to locate a point. This difficulty is resolved by use of longitude, which indicates east-west location.

There is no natural starting point for numbering longitude. Therefore the solution was to select an arbitrary starting point. When the natives of England began to make charts they chose the meridian through their principal observatory in Greenwich, England, as the zero line. This line has been adopted by most other countries of the world. The Greenwich meridian is sometimes called the first, or prime, meridian. Actually, it is the zero meridian.

Longitude is counted east and west from this meridian through 180 degrees. Thus the Greenwich Meridian is the zero degree longitude on one side of the earth, and after crossing the poles, it becomes the 180th meridian (180 degrees east or west of the 0-degree meridian). Therefore we have all longitudes designated either west or east (e.g., E 140 degrees or W 90 degrees). The E and W designations define the eastern and western hemispheres.

Each degree of latitude or longitude is divided into 60 minutes, and then either 60 seconds, or tenths and hundredths of minutes to more precisely locate a position on a circle.

This system is used to precisely locate any point on the earth's surface. When identifying a location by its position within this latitude-longitude matrix, you identify the position's *coordinates,* always indicating latitude first, then longitude. For example, the coordinates N 39° 04.1' W 95° 37.3' are read as “thirty-nine degrees, four point one minutes north latitude, ninety-five degrees, thirty-seven point three minutes west longitude.” If you locate these coordinates on *any* appropriate aeronautical chart of North America, you will *always* find Philip Billard Municipal Airport in Topeka, Kansas.

It is important to remember that in the northern hemisphere, latitude numbers increase as you proceed from south to north, and decrease as you move north to south. In the western hemisphere, longitude numbers increase when proceeding east to west, and decrease when moving west to east.

7.3 Magnetic variation

Variation is the angle between true north and magnetic north. It is expressed as east variation or west variation depending upon whether magnetic north (MN) is to the east or west of true north (TN), respectively. The north magnetic pole is located close to latitude 71 degrees N., longitude 96 degrees W. -- about 1,300 miles from the geographic or true north pole. If the earth were uniformly magnetized, the compass needle would point toward the magnetic pole, in which case the variation between true north and magnetic north could be measured at any intersection of the meridians.

Actually, the earth is not uniformly magnetized. In the United States the needle usually points in the general direction of the magnetic pole but it may vary in certain geographical localities by many degrees. Consequently, the exact amount of variation at thousands of selected locations in the United States has been carefully determined by the National Ocean Survey. The amount and the direction of variation, which change slightly from time to time, are shown on most aeronautical charts as broken red lines, called isogonic lines, which connect points of equal magnetic variation. The line connecting points at which there is no variation between true north and magnetic north is the agonic line.

7.4 Airspace

By analyzing air traffic volume at specific locations, the FAA determines the levels of control required to ensure safe, smooth operations at those locations. At or near some airports, the FAA has determined that the number of daily operations is so small that no central control is required. Near larger, busier airports centralized control by a control tower may be required not only for the aircraft departing and arriving the active runways, but for all the aircraft moving on the airport surface. At an airport with an operating control tower, the pilot must talk to clearance delivery or ground control and obtain a "taxi clearance" before moving the aircraft from its parking location. Similarly, a take off clearance must be received from the tower prior to moving onto and using the active runway.

If the pilot has filed a flight plan for flight under IFR he must receive clearance to conduct the flight from the FAA. The clearance includes the approved route of flight, altitude, and initial communications procedures.

For traffic management purposes, the FAA has designated that all airspace within the United States falls into one of six different class designations. Flight within each class requires certain communication, equipment, pilot experience, and, under some circumstances, weather requirements. Specific requirements for each class are complex, but they can be simplified somewhat with several broad generalizations.

Regardless of flight rules, the most stringent requirements normally are associated with flight in airspace immediately surrounding a major airport, due to the high density of operations conducted there. Observers should be alert for required communication when it appears a search will be conducted within 40 miles of a major airport or within 5 miles of any airport having an operating control tower. These are color-coded blue on sectional charts. Major airports in this context are generally near major metropolitan areas and appear at or near the center of concentric blue-, magenta-, or gray-colored circles.

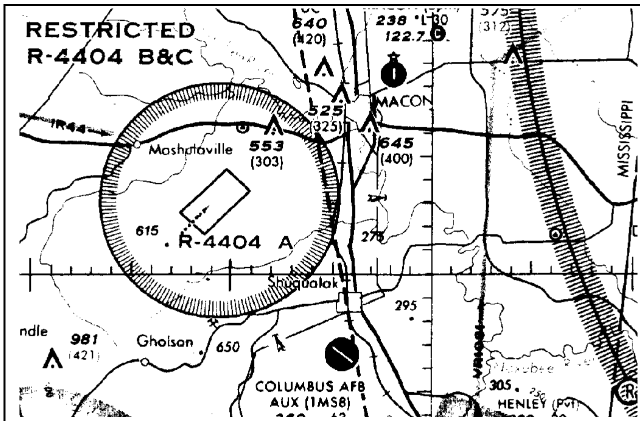


Figure 7-4

When operating the aircraft under VFR, in most classes of airspace the pilot can change the direction of flight or aircraft altitude without any prior coordination with air traffic control. This will almost always be the case when weather allows visual search patterns below the bases of the clouds. Regardless of the airspace classification, when the aircraft is operated under IFR, the pilot must receive a clearance from air traffic control prior to making any changes in direction, altitude, or route of flight.

7.4.1 Special Use Airspace

The FAA has designated some airspace as "special use" airspace. The FAA has specifically created special use airspace for use by the military, although the FAA retains control. Active special use airspace can become a navigational obstacle to search aircraft and uncontrolled objects within the airspace can present a serious threat to the safety of CAP aircraft and personnel. Special use airspace normally appears on sectional charts as irregularly shaped areas outlined by either blue or magenta hatched lines. It is also identified by either a name, such as Tyndall E MOA, or an alpha-numerical identifier like R-4404A.

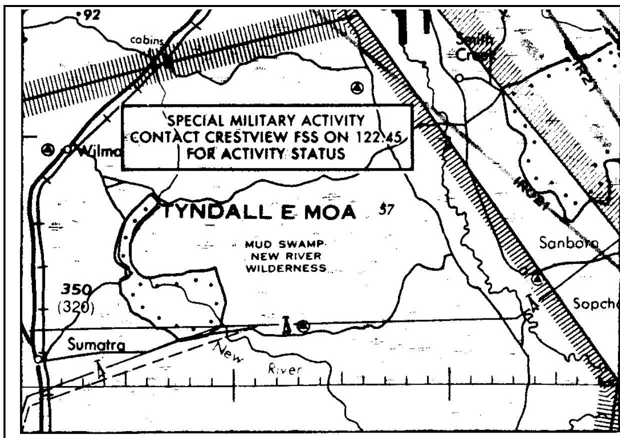


Figure 7-3

In the first example, the letters *MOA* indicate that the Tyndall E airspace is a *military operating area (MOA).* Within its boundaries the military may be conducting high-speed jet combat training or practicing air-to-ground weapons attack, without objects actually being released from the aircraft. Figure 7-3 illustrates how the MOA is portrayed on the sectional chart. MOA boundaries and their names are always printed in magenta on the sectional chart.

Civilian aircraft operating under VFR are *not* prohibited from entering an active MOA, and may do so at any time without any coordination whatsoever, although this practice is considered foolish by many pilots. As stated earlier, since the FAA retains control of the airspace, it is prudent to contact the controlling air traffic facility before continuing a search into any MOA.

Military aircraft at very low altitudes may not be in radar or radio contact with the air traffic controller, and he will not normally allow other IFR air traffic through an active MOA. The controller instead provides positive separation to civilian IFR aircraft from the MOA boundary, *not* from the military aircraft itself. This may force significant maneuvering off your intended course.

In the second example, the "R" prefix to the five-letter identifier indicates this is a *restricted* area. The Army may be conducting artillery firing within this airspace, or military aircraft may be practicing actual air-to-surface bombing, gunnery, or munitions testing. Shells, bombs, and bullets, as well as the dirt and fragments they throw into the air on impact, present a severe hazard to any aircraft that might come in their path. When a restricted area is active, that is, when the military is using the airspace, no other aircraft are allowed into that area under any conditions. Figure 7-4 illustrates how a typical restricted area is portrayed on the sectional chart. The restricted area's boundaries are always printed in blue.

Hours of use and vertical limits of special use airspace areas, as well as the FAA facility controlling each area, are printed in one of the margins of the sectional chart. If the CAP crew has any doubt about entering special use airspace, it should contact the appropriate air traffic control facility first to check the status of the area in question. The crew should *never* enter a restricted area unless *certain* military activity is not in progress.

7.4.2 Military Training Routes

Although not classified by the FAA as special use airspace, military training routes can have a similar adverse effect on a CAP team's ability to accomplish the briefed mission. An understanding of each type of training route, and the manner in which an active route can affect other traffic, will help the CAP team keep adverse effects to a minimum.

Military training routes that may be used by high-speed jet aircraft are identified by one of two designations depending upon the flight rules under which the military operates when working within that airspace. *Instrument routes* (IR) and v*isual routes (VR)* are identified on sectional aeronautical charts by medium-weight solid gray lines with an alpha-numeric designation. In Figure 7-5 there are two such examples east of the Clarksville Airport symbol -- IR-120, and VR-1102.

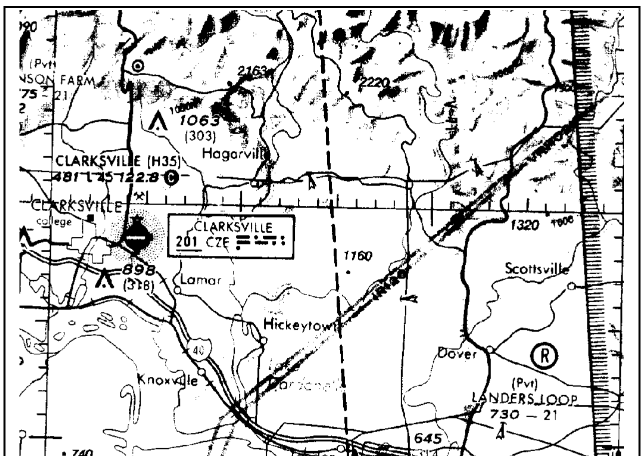


Figure 7-5

Only route centerlines are printed on sectional charts, but each route includes a specified lateral distance to either side of the printed centerline and a specific altitude "block." Route widths vary, but can be determined for any individual route by requesting Department of Defense *Flight Information Publication AP-1B*.

The letters *IR* in IR-120 indicate that military aircraft operate in that route according to IFR clearances issued by air traffic control. Other non-military VFR aircraft may enter the lateral or vertical boundaries of an active IR route without prior coordination, while aircraft operating IFR are kept out by air traffic control. Just as in the case of a MOA, air traffic control may not have radar and radio contact with the military aircraft using the route. Therefore, it is necessary to provide separation between other IFR aircraft and the route airspace regardless of where the military aircraft may be located along the route. This may force either a route or altitude change. Civil Air Patrol members can request the status of IR routes from the controlling air traffic facility.

The letters *VR* in VR-1102 indicate that the military operates under VFR when operating within the lateral and vertical limits of that airspace. The see-and-avoid concept applies to *all* civilian and military aircraft operating there, and all crew members must be vigilant in visual lookout when within or near a VR training route. Many military missions go to and from visual training routes' start and exit points on IFR clearances, and the prudent crew can inquire about the status of the route with air traffic control when operating through or near a VR training route.

You can determine *scheduled* military activity for restricted areas, MOAs, and on military training routes by checking *Notices to Airmen*. However, checking with the air traffic control facilities is preferable, since it will reveal *actual,* "real time" activity versus *scheduled* activity. When flying through any special use airspace or training route, crewmembers should be cautious at all times. Never assume that ATC will warn you of approaching traffic, and never assume that low-flying, high-speed military aircraft will either be looking for you or be able to see you.

7.4.3 Special Coordination and Communication

The procedures the FAA has developed to help manage air traffic, from a practical viewpoint, are primarily oriented towards an operator moving an aircraft between two points. They frequently can constrain flights whose primary purpose is different. In many cases, the FAA has lesser-known procedures in place that may allow operations that seem contrary to the standard.

If fulfilling a special requirement does not involve deviating from FAA regulations, in many cases a personal telephone call by the incident commander to the facility in question, with an explanation of the requirement, can lead to FAA concurrence on a temporary procedure. Crewmembers, especially pilots, must be careful that temporary procedures do not violate FAA regulations. An air traffic controller or supervisor has the authority to authorize deviations from FAA regulations in only a very few circumstances.

7.5 Electronic Aids to Navigation (Navaids)

The most important part of using any navigation method is starting from a known position or *fix.* Obviously, if you don't know precisely where you are to start with, you can't very well know the right direction and distance to travel in order to reach the next landmark. Likewise, if you fly a 050° heading for 16 minutes, but you don't know where you started from, the dead reckoning will most likely be futile. This section will cover some of the electronic means available that can help in navigating. These systems help you determine your position in reduced visibility or over featureless terrain and, more importantly, help you fly precise search patterns and accurately report your observations to ground teams or the mission base.

Most airplanes flown in today's environment have equipment that provide a means of navigation and communication with ground stations (nav-comms). Advances in navigational radio receivers (particularly GPS) in airplanes, the development of aeronautical charts which show the exact location of ground transmitting stations and their frequencies, along with refined cockpit instrumentation make it possible for aircrews to navigate with precision to almost any point desired.

7.5.1 Automatic direction finder (ADF)

The automatic radio compass, generally known as the Automatic Direction Finder (ADF), is used to receive radio guidance from stations such as four-course ranges, radio beacons, and commercial broadcast facilities. The automatic direction finder indicates the direction of the station being received. This direction is shown in relation to the heading of the aircraft. Operation of the automatic direction finder is based on the direction-finding characteristics of the loop antenna. When the plane of the loop is located at right angles to an imaginary line extending to the transmitting station, the signals received are very weak. With the plane of the loop antenna perpendicular to the longitudinal axis of the aircraft, only weak signals are received when the aircraft is headed either toward or away from a tuned station. The ADF indicating needle then points to zero, showing that the aircraft is on course to the tuned station.

Probably the most common use of the automatic direction finder is in “homing”. The pilot tunes in a desired station, then flies directly to that station by keeping the ADF indicating needle on the zero mark. When the needle points to the zero mark, the aircraft is headed toward the station. When the station is passed, the needle will swing around to the 180 degree position, indicating that the station is behind. The pilot may also tune to two or more stations and plot the bearings received on an aeronautical chart to fix his position. He may also tune to a single station, obtain a bearing, and combine this line of position with a radio range signal to fix his position. Although ADF does not compensate for wind drift and is vulnerable to static, it is a valuable radio navigation aid in cross-country flying.

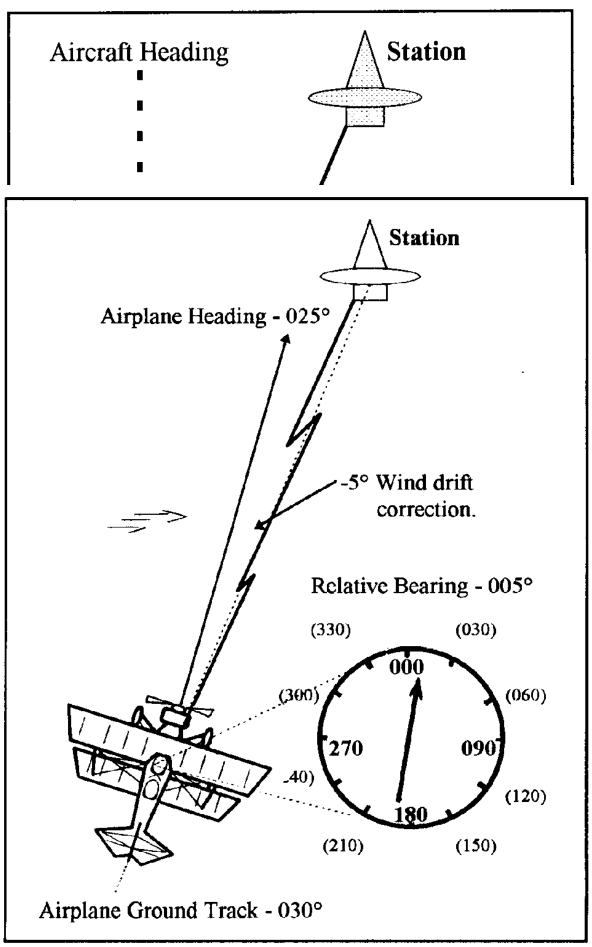


Figure 7-8

The automatic direction finder (ADF) has three primary components -- a transmitter on the ground, a receiver and an indicator, both in the aircraft. Transmitters include NDB, or non-directional radio beacons, and commercial AM radio stations. Each transmitter emits a single signal on a specific frequency in all directions. ADF equipment aboard the aircraft indicates the *relative* bearing of the station, or its relative direction from the aircraft. In Figure 7-6, the airplane is shown flying north, or flying both a heading and a course of 000°. The ADF “indicator” illustrated shows the direction to the transmitter is 30 degrees to the right of the plane's nose. In the illustration only 0, 090, 180, and 270 are shown on the indicator, and that is true of many ADF indicators. You may have to interpret index marks between these major bearings to determine the exact bearing to the station.

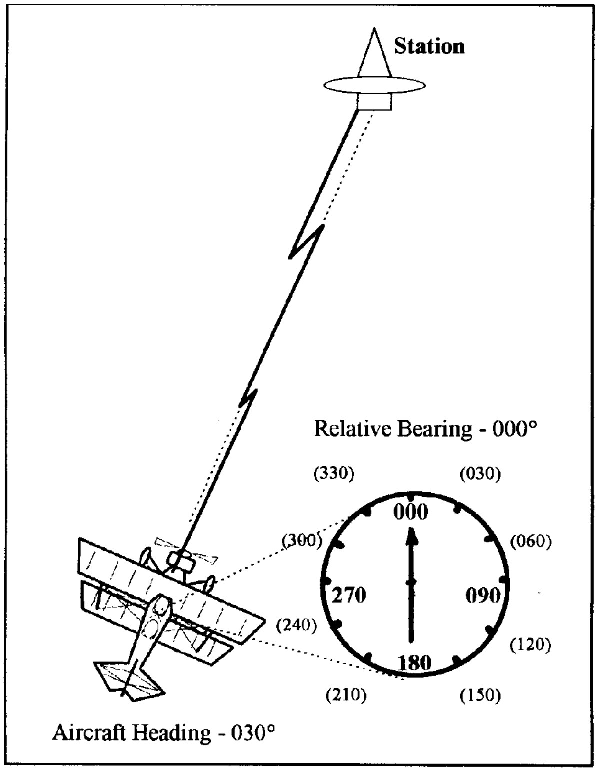


Figure 7-7

If you turn the aircraft 30 degrees to the right, to a heading of 030°, the plane will point directly at the station, and the pointer will now point at 0 relative bearing. In a no-wind condition, if you maintained that 030° heading and the pointer at 0 relative bearing, you would fly directly to that transmitter, as shown in Figure 7-7.

In a crosswind, the pilot estimates the airplane's drift, and computes a drift correction factor to be added to or subtracted from the aircraft heading. If he estimates 5 degrees of drift to the right, his drift correction will be to subtract 5 degrees from the airplane's heading, and turn the aircraft 5 degrees to the left. The aircraft would thus have a heading of 025°, its course over the ground would remain 030°, and the ADF would show a relative bearing of 005°, or 5 degrees to the right, as shown in Figure 7-8. In the rowboat-crossing-the-river analogy, the boat's bow points upstream, but due to the current it travels in a straight line across the river. The aim point is slightly to the right of the bow as the boat proceeds across.

When tracking, unless the effect of wind is taken into account, the airplane will follow a curved path. Slight amounts of wind and drift can be difficult to detect, and a *slightly* curved path may result regardless, but the crew should try to keep the curve to a minimum because it wastes both time and fuel. When the aircraft passes over the station, the pointer will swing from approximately 000 degrees to approximately 180 degrees relative bearing.

This system is only good for proceeding directly to or from the station. Returning to the northbound airplane in Figure 7-8, the stations initial relative bearing was determined to be 30 degrees right. When the compass showed a heading of 000°, it was necessary to add 30 degrees to determine a *magnetic bearing* to the station. When the magnetic bearing *to* the station is 030 degrees, the aircraft's "mag" bearing *from* the station is the reciprocal of 030°, or 210°. To determine the reciprocal, add or subtract 180°. If you then locate the station or NDB on the sectional and apply the magnetic variation to determine your true bearing from the station, you can draw a line of position on the chart.

With another line of position from a different station, you can find your location where the two lines intersect. It requires a great deal of proficiency to do this accurately using one receiver, but using a second ADF or another type of navigation radio makes the process easier.

All ADF stations transmit an audible identifier that you must identify before using the signal for navigation. All ADFs are highly susceptible to interference when thunderstorms are in the general vicinity, and their transmissions are restricted to line-of-sight only. Signals can be blocked by terrain or other obstructions, especially when the aircraft is operating at low altitudes.

The requirement for aircraft to have an ADF unit is being phased out as use of the GPS becomes more widespread.

7.5.2 Very High Frequency Omnidirectional Range (VOR)

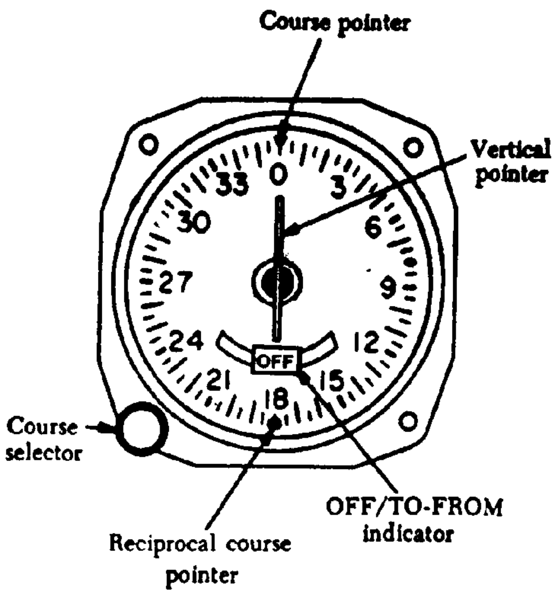


Figure 7-9

Very high frequency omnidirectional range (VOR) is a more accurate radio navigation system. Each operates on a specific frequency in the VHF range of 109.0 to 117.9 megahertz and transmits 360 directional radio beams or *radials* that, if visible, would resemble the spokes radiating from the hub of a bicycle wheel. Each station is aligned to magnetic north so that the 000 radial points from the station to magnetic north. Every other radial is identified by the magnetic direction to which it points from the station, allowing the pilot to navigate directly to or from the station by tracking along the proper radial.

Like the ADF, the main components are in three pieces: the ground transmitter, the receiver, and the indicator. Controls on the receiver include a power switch, frequency selector knobs and display window, and a volume control.

To help pilots plan and choose routings, the FAA has developed the Victor airway system, a “highway” system in the sky that uses specific courses to and from selected VORs. When tracing the route of a missing aircraft, search airplanes may initially fly the same route as the missing plane, so it is very important you know the proper procedures for tracking VOR radials.

Figure 7-9 shows a VOR indicator and the components that give the information needed to navigate, including a vertical pointer, OFF/TO-FROM flag or window, and a course-select knob. The vertical pointer, also called a course deviation indicator (CDI), is a vertically mounted needle that swings left or right to show the airplane's location in relation to the course selected beneath the course pointer. The OFF/TO-FROM indicator shows whether the course selected will take the airplane to or from the station. When it shows “OFF”, the receiver is either not turned on or it’s not receiving signals on the selected frequency. The course selector knob is used to select the desired course to fly either toward or away from the station.

Flying to the VOR station is simple. Find the station’s frequency and its Morse code audio identifier using the sectional chart. Next, tune the receiver to the correct frequency and identify the station by listening to its Morse code. If you can’t positively identify the station, you should not use it for navigation.

After identifying the station, slowly turn the course selector knob until the TO-FROM indicator shows TO and the CDI needle is centered. If you look at the course that's selected beneath the course pointer at the top of the indicator, you'll see the course that will take you directly to the station. The pilot turns the aircraft to match the airplane's heading with that course and corrects for any known winds by adding or subtracting a drift correction factor. The pilot keeps the CDI centered by using very small heading corrections and flies the aircraft directly to the station. When the aircraft passes over the station, the TO-FROM indicator will flip from TO to FROM.

To fly away from a station, tune and identify the VOR, then slowly rotate the course select knob until the CDI is centered with a FROM indication in the window. Look at the selected course, again normally at the top of the indicator, to determine the outbound course. The pilot turns the aircraft to that heading, corrects for wind drift, and keeps the CDI needle in the center to fly directly away from the station.

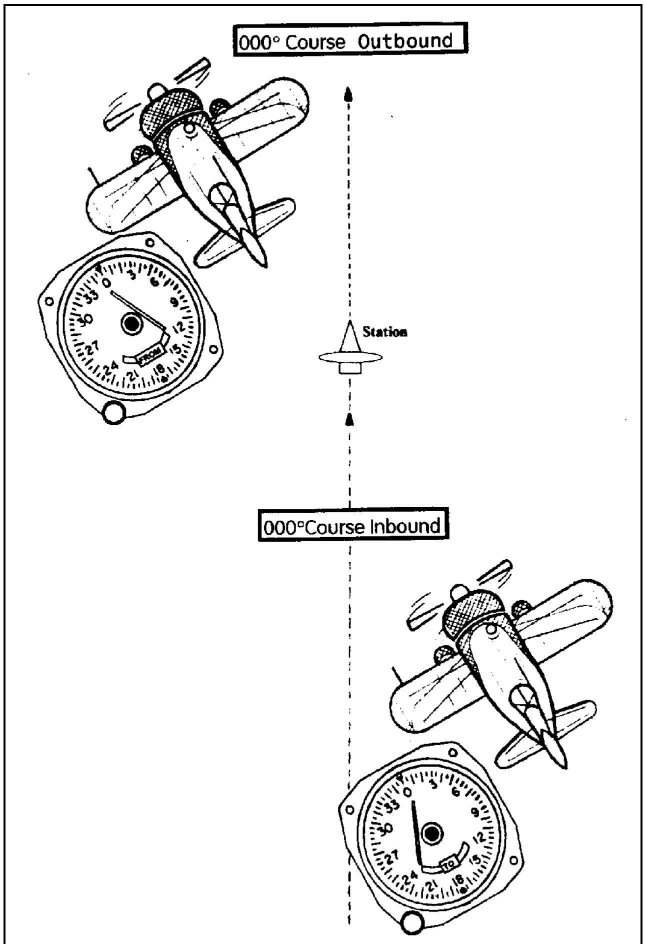


Figure 7-10

Figure 7-10 shows a hypothetical VOR with the 0° inbound and outbound courses simulating a Victor airway. In order to fly that airway, set 0° beneath the course pointer and determine the aircraft's position relative to the selected course. Each airplane has the 0° course selected under its course pointer, but the top airplane has a "FROM" indication. This indicates that the plane is north of the station. The vertical pointer's right deflection indicates that the desired 0° course from the station is off to the right. Since the plane is flying about a 330° heading, the pilot would turn back to the right to join the 0° course outbound from the station.

The indicator in the airplane southeast of the station has a "TO" indication, which, with the 0° course selected, indicates it's south of the station. The pointer's left deflection indicates the 0° course to the station is to the plane's left. Since this plane also is heading 330°, it does not need to turn farther to *intercept* the 0° course to the station.

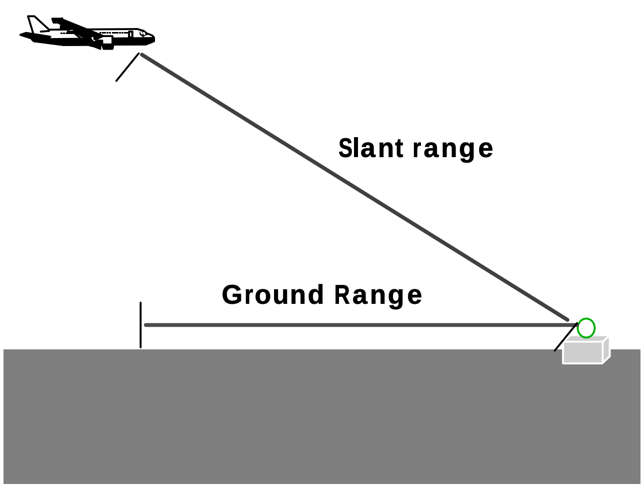
The display in the north plane would show the same indications if it were heading 360° or 030°, since in any case the 0° course from the station is still to the right. Likewise, the south plane would have the same indications regardless of the direction it's pointed. <u>At any given point in space, the VOR display always gives the same indication regardless of the direction the airplane is pointing.</u>

VOR can be used like ADF to determine a position in relation to a selected station, and the process is considerably simpler due to the directional nature of the VOR's signals. Rotate the course select knob slowly until the CDI is centered with a FROM indication, and look beneath the reciprocal course pointer for the radial. You can draw that radial as a line of position from the station's symbol on the sectional chart.

Each VOR station on the chart has a surrounding compass ring already oriented towards magnetic north. Therefore, it isn't necessary to correct for magnetic variation. The use of the printed compass circle surrounding the station on the chart eliminates the need for using the plotter's protractor as well. Use any straight edge to draw the radial by connecting the station symbol with a pencil line through the appropriate radial along the circle. The radial drawn on the chart shows direction, but does not indicate distance from the station. But, you can get an accurate position "fix" by repeating the procedure with another VOR.

Using VOR has several advantages over using ADF. The directional nature of the VOR transmissions makes them easier to use for navigation than the non-directional signal from a NDB. Signals from VORs are also much less susceptible to interference from thunderstorms and static electricity produced by weather phenomena. The directional signals from VOR's also make it much easier to correct for crosswinds. Like ADF, VOR is limited by signal blockage from high terrain and obstructions, or during flight at very low altitudes.

7.5.3 Distance Measuring Equipment (DME)



Finding bearing or direction to a station solves only one piece of the navigation puzzle. Knowing the distance to the station is the final piece to the puzzle that allows fliers to navigate more precisely. You can use crossing position lines from two radio stations to obtain your distance from the stations, but an easier method is provided by distance measuring equipment (DME).

DME continuously measures the distance of the aircraft from a DME ground unit that is usually co-located with the VOR transmitter (called a VORTAC). The system consists of a ground-based receiver/transmitter combination called a transponder, and an airborne component called an interrogator. The interrogator emits a pulse or signal, which is received by the ground-based transponder. The transponder then transmits a reply signal to the interrogator. The aircraft's DME equipment measures the elapsed time between the transmission of the interrogator's signal and the reception of the transponder's reply and converts that time measurement into a distance.

This measurement is the actual, straight-line distance from the ground unit to the aircraft, and is called *slant range*. This distance is continuously displayed, typically in miles and tenths of miles, on a dial or digital indicator on the instrument panel. When DME is used in combination with VOR, a pilot can tell at a glance the direction and distance to a tuned station.

Since DME measures straight-line distance, or slant range, there is always an altitude component within the displayed distance. If you fly toward a station at an altitude of 6,000 feet over the station elevation, the DME will never read zero. It will continuously decrease until it stops at one mile. That mile represents the aircraft's altitude above the station. The distance readout will then begin to increase on the other side of the station. Under most circumstances the altitude component of slant range can be ignored, but when reporting position using DME, especially to air traffic controllers, it is customary to report distances in "DME", not nautical miles, e.g., "Holly Springs 099° radial at 76 DME."

Some DME equipment can also compute and display the actual ground speed of the aircraft, provided that the aircraft is flying directly to or from the ground station. In all other circumstances, the ground speed information is not accurate and should be ignored.

7.5.4 LORAN

Long Range Navigation (LORAN) is a navigational system that utilizes low frequency radio stations to determine the aircraft position with, under most conditions, considerably greater accuracy than ADF, VOR, or DME. It operates in the 90 to 110 kHz frequency band and is based upon measurement of the difference in time of arrival of radio frequency energy pulses. These pulses are radiated by a chain of transmitters that are separated by hundreds of miles. Within a chain, one station is designated as the master station (M), and the other stations are designated as secondary stations as shown in Figure 7-11. Signals transmitted from the secondary stations are synchronized with those from the master station. The measurement of a time difference (TD) is made by a receiver that compares a zero crossing of a specified radio-frequency cycle within the pulses received from the master and secondary stations of a chain. Loran provides predictable accuracy of 0.25 nautical miles or better, depending on the user's location within the signal coverage area in certain coastal regions of the chain.

The basic operating principle is that radio waves travel through the atmosphere at near constant speed. You may recall from the dead reckoning lesson that speed and time can be used to determine the distance traveled from a known start point. Similarly, a LORAN radio precisely measures the amount of time required to receive a radio signal from the instant it's transmitted, and uses the known speed of the radio waves to determine the distance from that transmitter.

A LORAN system consists normally of no fewer than three ground-based transmitters and three airborne components -- a receiver, time measuring device, and a digital computer processor. The receiver, time measuring device, and processor are normally enclosed within the same case by the manufacturer, with a control panel and indicators on the front of the case. Transmitters are collectively known as a *chain*, and

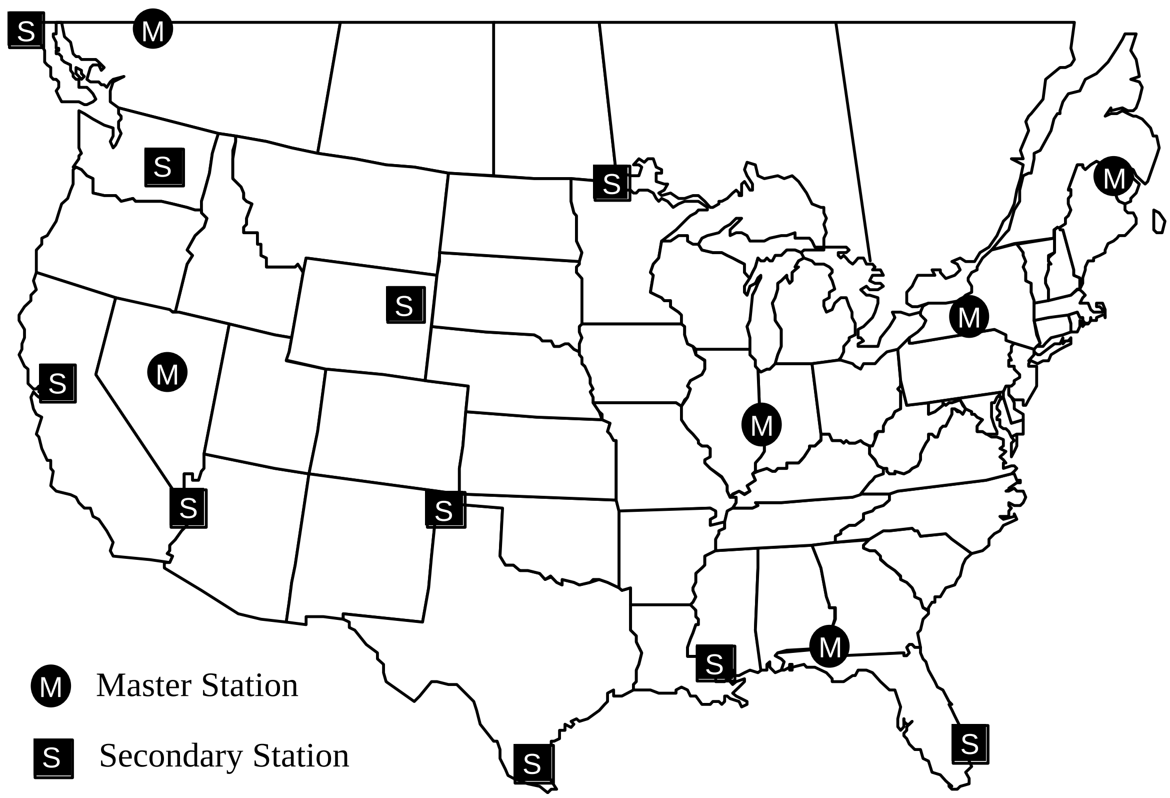


Figure 7-11

operate within the chain as either the master primary transmitter or as one of the slave secondary transmitters. Each chain must have one master transmitter and at least two slave transmitters.

A LORAN master station transmits a signal, which is echoed by each slave station at a precise, predetermined time interval. The airborne receiver component receives the signal first from the master transmitter, followed by the signals from each slave station. The time measuring device determines the time differences between reception of the master signal and each slave signal. The processor converts these time measurements into distances, and then computes the receiver position by mathematically triangulating the calculated distances from the known positions of the stations. For clarity from this point on, all the airborne components will be referred to collectively as the receiver.

Although the individual features of LORAN receivers may vary according to the manufacturers' designs, almost all have digital readouts where the pilot or observer can directly read the latitude and longitude coordinates of the receiver's/aircraft's present position. Most systems have additional navigational features that can be very useful on search and rescue missions. LORAN features may include programmable waypoints, course deviation and ground speed readouts, and a capability to "freeze" or "mark" the present position display only, while the receiver and processor continue to calculate updates.

The utility of these systems on a visual search is limited only by the system's individual features and the imagination of the crew using the system. For instance the aircrew can program two or more navigational points into the system and use it to fly the base segment for either a parallel track or creeping line search pattern with significantly increased accuracy. Then using the course deviation or track error features, the crew can more precisely fly every successive leg at the track spacing directed by the incident commander. Then after locating a possible lead or the crash site itself, they can use the "freeze" or "mark" function when directly overhead the site and accurately obtain coordinates of the location.

LORAN systems, while having great utility, are vulnerable to certain system problems that can degrade their performance. Because the transmitters are ground-based, high terrain or obstructions between the transmitters and the receiver can block the signal. Ground interference can similarly affect signal reception at very low altitudes even over flat terrain, depending upon the receiver's distance from the chain stations. Signals are also vulnerable to interference from severe electrical storms. Frequently, when the receiver momentarily loses one or more of the stations, the displayed position stays at the last position prior to the signal loss. When the lost signal is acquired again, the calculations resume and the correct position will return. In the interim, however, the "stuck" position is not updating and can give the crew an erroneous indication. Crewmembers are also cautioned to check the instructions of the individual LORAN for the stored chain data. Ground station frequencies and time-delay intervals used within the chains in many cases cannot be “tuned” by the crew, having been permanently programmed by the manufacturer instead.

The FAA has not approved all LORAN receivers for use in instrument flight conditions, and CAP does not have any IFR-certified LORAN units. A small placard or label on the aircraft instrument panel will list the conditions for use. Unless you are *certain* the receiver and its installation are approved for operations in instrument conditions, LORAN should only be used in visual weather conditions.

LORAN should complement navigational techniques previously discussed and should not be used as a sole substitute for good pilotage and dead reckoning. To a new operator, many LORANs are not "user friendly" and can significantly <u>increase</u> the user's workload. Crewmembers anticipating LORAN use should read the operating manual or instructions and become thoroughly familiar with LORAN operation before flight, so that operating the LORAN will not become a distraction from more important tasks.

LORAN units are being replaced by GPS in all CAP aircraft.

7.5.5 Global Positioning System (GPS)

Initially developed by the Department of Defense for military users, the Global Positioning System is a navigational system that is quickly becoming the standard navigational system for aircraft. The GPS represents a tremendous improvement in search and rescue/disaster assessment capabilities by enabling us to fly precisely without reference to ground features. This increases search effectiveness in terms of search coverage, fuel efficiency, and safety. For this reason, all pilots and observers must become thoroughly familiar with their GPS unit's capabilities and integrate the GPS into their missions.

The system relies on a chain of 24 satellite transmitters in polar orbits about the earth. The speed and direction of each satellite, as well as each satellite's altitude, is precisely maintained so that each satellite remains in a highly accurate and predictable path over the earth's surface at all times.

GPS receivers process signals transmitted by these satellites and triangulate the receiver's position, which the user again can read directly in latitude and longitude coordinates from a digital display. Similar additional features as those discussed in LORAN are available and vary depending upon the design and manufacturer. The system is substantially more accurate than LORAN, VOR, DME, or ADF and has several advantages.

Because the transmitters are satellite based, not ground based, and the signals are essentially transmitted *downward,* system accuracy is not significantly degraded in mountainous terrain. Additionally, the system is not normally vulnerable to interference from weather or electrical storms. Receivers can typically process more than eight received signals simultaneously, and can automatically deselect any satellite whose signal doesn't meet specific reception parameters. The system can function with reasonable accuracy using as few as three received signals.

As certain limitations are overcome, IFR-certified GPS units will replace the ADF and VOR systems. CAP aircraft, however, are equipped with VFR-only GPS units, so they will have to maintain the ADF and VOR units in order to be instrument-certified aircraft. Operations using GPS should be conducted only in VFR flight conditions, and should be complemented by other navigational techniques. GPS should not be used as the sole navigational instrument.

7.6 Sectional Charts

The most important tool you will use in both mission planning and execution is the chart. Although the earth is spherical, not flat, cartographers can portray small portions of the earth's surface as though it *is* a flat surface, without affecting accurate navigation. Visual air navigation charts must have certain basic features including:

- Navigational reference system superimposed over the terrain depiction.
- Identifiable, measurable scale to measure distances.
- Detailed graphic depiction of terrain and culture, or man-made features.

Highway road maps are usually not acceptable for air navigation, since most don't have detailed terrain depiction and also lack the superimposed reference system. Many aeronautical charts have such small scales that the makers are unable to show required levels of detail when trying to put a large area into a small chart space. The most useful chart that has been widely accepted for visual, low-altitude navigation is the *sectional aeronautical chart,* sometimes simply referred to as the *"sectional".*

Sectionals use a scale of one to five hundred thousand, or 1:500,000, where all features are shown 1/500,000 of their actual size. This allows accurate depiction of both natural and cultural features without significant clutter.

Sectionals portray the following:

- physical, natural features of the land, including terrain contours, or lines of equal elevation.
- man-made or cultural development, like cities, towns, towers, and race tracks.
- navigational radio stations, airways, and military-use airspace.
- radio frequencies, airport data, lines of magnetic variation, and other important information.

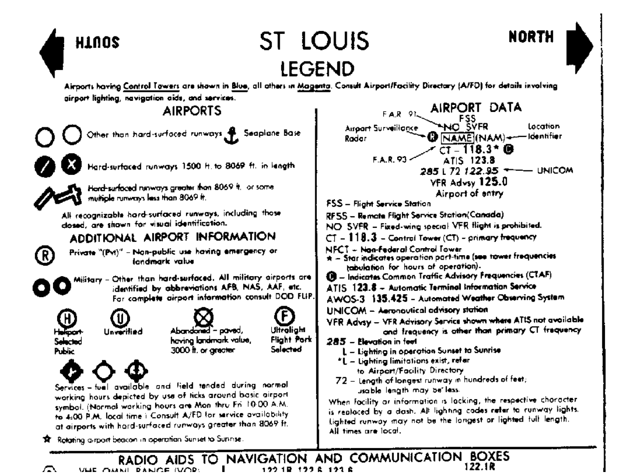


Figure 7-12

The most important part of the sectional or any other chart is the legend. This is a written explanation of symbols, projections, and other features used on the chart. Figure 7-12 illustrates a portion of the St. Louis sectional chart legend. Other important areas of the sectional chart are its title page or "panel", and the margins around the chart edges. The margins contain supplemental radio frequency information, details about military or *special use airspace,* and other applicable regulations. The title panel identifies the region of the country shown by the chart, indicates the scale used in drawing the chart, explains elevations and contour shading, and shows the expiration date of the chart and effective date of the next issue of that chart. Expired charts should not be used on missions because information on the charts may no longer be correct.

The National Ocean Survey (NOS) publishes and sells aeronautical charts of the United States and of foreign areas. The type of charts most commonly used by VFR pilots are:

- Sectional Charts. The scale of the Sectional Chart is 1:500,000 (1 inch = 6.86 NM)
- VFR Terminal Area Charts. The scale of a VFR Terminal Area Chart is 1:250,000 (1 inch = 3.43 NM).

These charts are designed for visual navigation of slow/medium speed aircraft. The topographical information featured on these charts consists of the portrayal of relief and a judicious selection of visual checkpoints used for VFR flight. The checkpoints include populated places, drainage, roads, railroads and other distinctive landmarks.

The aeronautical information on sectional charts includes visual and radio aids to navigation, airports, controlled airspace, restricted areas, obstructions and related data.

VFR Terminal Area Charts depict Class B airspace on a scale of 1:250,000. One side of the chart shows information similar to that found on a sectional chart, but in greater detail. The other side is a charted VFR flyway planning chart, which identifies VFR flyways designed to help VFR pilots avoid major controlled traffic flows; these may be used as alternates to flight within the established Class B airspace. Its ground references provide a guide for improved visual navigation. The chart is for information and planning purposes only.

Both the Sectional and VFR Terminal Area Charts are revised semi-annually. Information on the charts change more frequently than this, and consolidated updates are available every 56 days in the Airport/Facility Directory (A/FD). Aircrews can also consult appropriate Notices to Airmen (NOTAMs) and other Flight Information Publications (FLIPs) for the latest changes.

It is vitally important that pilots check the publication date on each aeronautical chart to be used. Obsolete charts should be discarded and replaced by new editions. This is important because revisions in aeronautical information occur constantly. These revisions include changes in radio frequencies, new obstructions, temporary or permanent closing of certain runways and airports, and other temporary or permanent hazards to flight. To make certain that the sectional aeronautical chart being used is up-to-date, refer to the National Ocean Survey (NOS) Aeronautical Chart Bulletin in the Airport/Facility Directory (A/FD). This bulletin provides the VFR pilot with the essential information necessary to update and maintain current charts. It lists the major changes in aeronautical information that have occurred since the last publication date of each chart:

- changes to controlled airspace.
- changes special use airspace that present hazardous conditions or impose restrictions on the pilot.
- major changes to airports and to radio navigational facilities.

7.7 Chart Interpretation

A significant part of air navigation involves interpreting what one sees on the chart, then making comparisons outside the aircraft. It is most important that observers be thoroughly acquainted with the chart symbology explained in the chart legend, and the relief information discussed on the chart's title panel.

Basic chart symbology can be grouped into cultural features, drainage features, and relief features. Understanding cultural features is straightforward, and they usually require little explanation. Villages, towns, cities, railroads, highways, airports or landing strips, power transmission lines, towers, mines, and wells are all examples of cultural features. The chart legend explains the symbology used for most cultural features, but if no standard symbol exists for a feature of navigational significance, the cartographer frequently resorts to printing the name of the feature itself, such as *factory* or *prison,* on the chart.

Drainage features on charts include lakes, streams, canals, swamps, playas, and other bodies of water. On sectionals these features are represented by light-weight solid blue lines for rivers and streams. Large areas of water, such as lakes and reservoirs, are shaded light blue with the edges defined by light-weight solid blue lines. Under most conditions, the drainage features on a map closely resemble the actual bodies of water. However, certain bodies of water may change shape with the season, or after heavy rains or drought. Where this shape change occurs with predictability, cartographers frequently illustrate the maximum size expected for a body of water with light-weight blue, dashed lines. If you intend to use drainage features for navigation, you should consider recent rains or dry spells while planning and remember the body of water may not appear exactly as depicted on the chart.

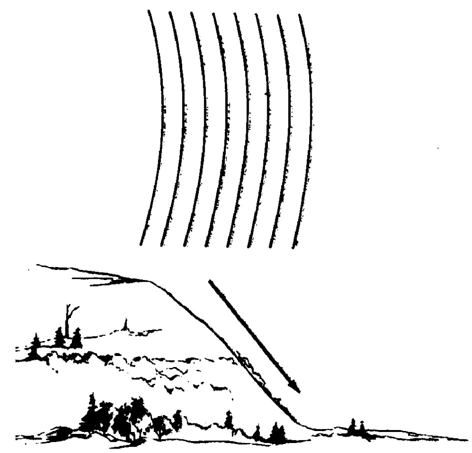


Figure 7-13

7.7.1 Relief

Relief features indicate vertical topography of the land including mountains, valleys, hills, plains, and plateaus. Common methods of depicting relief features are contour lines, shading, color gradient tints, and spot elevations. Contour lines are the most common method of depicting vertical relief on charts. Although the lines do not represent topographical features themselves, through careful study and interpretation you can predict a feature's physical appearance. Each contour line represents a continuous imaginary line on the ground on which all points have the same elevation above or below sea level, or the zero contour. Actual elevations above sea level of many contour lines are designated by a small break in the line, while others are not labeled. Contour interval, or the vertical height between each line, is indicated on the title panel of sectionals.

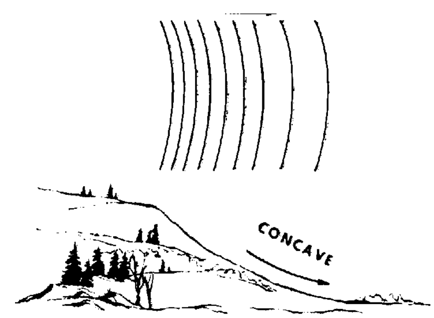


Figure 7-14

Contour lines are most useful in helping us to visualize the vertical development of land features. Contour lines that are grouped very closely together, as in Figure 7-13, indicate rapidly changing terrain, such as a cliff or mountain; more widely spaced lines indicate more gentle slopes. The absence of lines indicates flat terrain.

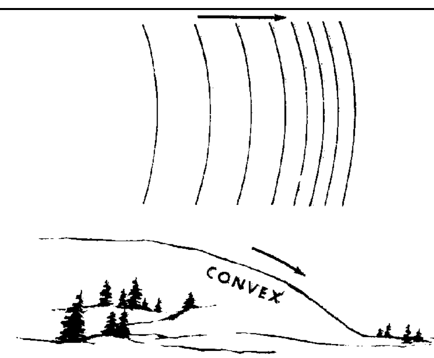


Figure 7-15

Contour lines can also show changes in the slope of terrain. Figures 7-14 and 7-15 show how to predict the appearances of two hillsides based upon their depictions on a chart.

Precise portrayal and interpretation of contour lines allows accurate prediction of the appearance of the terrain you expect to fly over or near. Figure 7-16a shows the depiction of a saddle in a short ridgeline, and Figure 7-16b shows how it might appear from the aircraft. Many other types of terrain features can be predicted by careful study

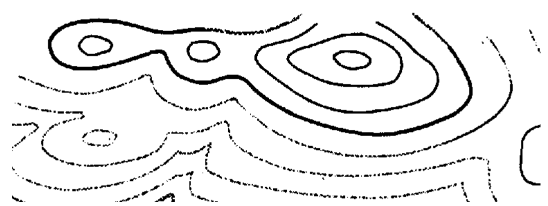


Figure 7-16a


Figure 7-16b

of contour lines. An outdated chart can be a useful tool for helping to develop your skills, but don't use it for navigation in flight.

Shading is added to sectional charts to help highlight and give contrast to the contour lines. These tiny gray dots are applied adjacent to selected contour lines and give the contours a three-dimensional appearance. This makes it easier to imagine the physical appearance of the shaded topographical feature.

Gradient tints, the "background" colors on charts, indicate general areas of elevation. The height range assigned to each gradient color is indicated on the title panel of each sectional chart. Areas that are near sea level are pale green, while high terrain is color-coded a deep red/brown. Intermediate elevations are indicated by brighter shades of green, tan, or lighter shades of red/brown.

A spot elevation is the height of a specific charted point. On sectional charts, this height is indicated by a number next to a black dot, the number indicating the height of the terrain above sea level.

7.7.2 Aeronautical Data

The aeronautical information on the sectional charts is for the most part self-explanatory. Information concerning very high frequency (VHF) radio facilities such as tower frequencies, omnidirectional radio ranges (VOR), and other VHF communications frequencies is shown in blue. A narrow band of blue tint is also used to indicate the centerlines of Victor Airways (VOR civil airways between omnirange stations). Low frequency-medium frequency (LF/MF) radio facilities are shown in magenta (purplish shade of red).

In most instances FAA navigational aids can be identified by callsigns broadcast in International Morse Code. VOR stations and Non-directional Radio Beacons (NDB) use three-letter identifiers which are printed on the chart near the symbol representing the radio facility.

Runway patterns are shown for all airports having permanent hard-surfaced runways. These patterns provide for positive identification as landmarks. All recognizable runways, including those that may be closed, are shown to aid in visual identification. Airports and information pertaining to airports having an airport traffic area (operating control tower) are shown in blue. All other airports and information pertaining to these airports are shown in magenta adjacent to the airport symbol which is also in magenta.

The symbol for obstructions is another important feature. The elevation of the top of obstructions above sea level is given in blue figures (without parentheses) adjacent to the obstruction symbol. Immediately below this set of figures is another set of lighter blue figures, enclosed in parentheses, which represents the height of the top of the obstruction above ground level. Obstructions which extend less than 1,000 feet above the terrain are shown by one type of symbol and those obstructions that extend 1,000 feet or higher above ground level are indicated by a different symbol (see sectional chart). Specific elevations of certain high points in terrain are shown on charts by dots accompanied by small black figures indicating the number of feet above sea level.

The chart also contains larger bold face blue numbers which denote Maximum Elevation Figures (MEF). These figures are shown in quadrangles bounded by ticked lines of latitude and longitude, and are represented in THOUSANDS and HUNDREDS of feet above mean sea level. The MEF is based on information available concerning the highest known feature in each quadrangle, including terrain and obstructions (e.g., hills, towers and antennas).

An explanation for most symbols used on aeronautical charts appears in the margin of the chart. Additional information appears at the bottom of the chart.

7.8 Chart Preparation

Careful chart preparation and route study before the flight can increase your efficiency and decrease your workload during the flight. You should try to develop a systematic approach to chart preparation. Thorough preparation is necessary, even with the advent of Global Positioning System (GPS) technology.

The first step in planning any leg is to locate the departure point and destination on the chart, and lay the edge of a special protractor, or plotter, along a line connecting the two points, as shown in Figure 7-17. Read the true course for this leg by sliding the plotter left or right until the center point, or grommet, sits on top of a line of longitude. When the course is more to the north or south, you can measure it by centering the grommet on a parallel of latitude, then reading the course from the inner scale that's closer to the grommet.

The discussion that follows concerns one leg of a flight from University-Oxford airport, near Oxford, Mississippi, to the Ripley airport, near Ripley, Mississippi. The same basic principles used in planning this single leg are used in all air navigation and apply to more complex search patterns.

In Figure 7-18, the chart for this "flight," two points are connected with a solid line. This line represents the *true* course from Oxford to Ripley and is 051°. If you were interested in going the opposite direction, the course would be the *reciprocal* course, 231°, which also appears on the arc of the plotter. Remain aware of the relationship among general directions -- north, east, south, and west -- and their directions indicated by degrees on the compass -- 000°, 090°, 180°, and 270°, respectively. Since almost all charts are printed with north to the top of the chart, you can look at the intended direction of flight, which runs right and up, or to the northeast, and know immediately that 051° is correct and 231° is not.

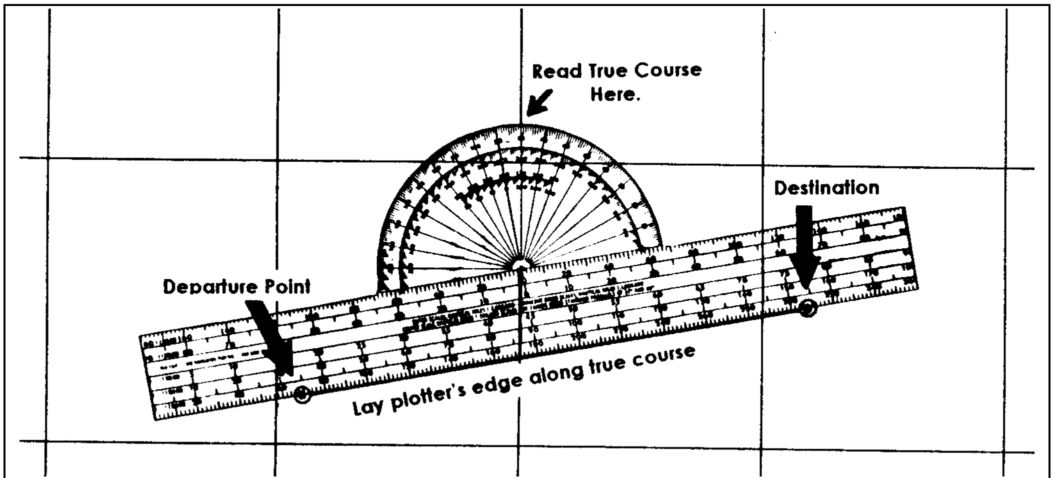


Figure 7-17

Notice the broken line that nearly passes through the Oxford airport symbol, and follow it toward the bottom of the page. Near the bottom, you'll see the numbers 1°30' E. This is the magnetic variation correction factor for that area.

If you subtract east variation or add west variation to the true course, you can determine the magnetic course. Most fliers advocate writing the "mag" course right on the chart. Round 1° 30' down to 1° and subtract that from the true course to obtain 050° for the magnetic course. Also notice that Oxford is within the boundaries of the Columbus 3 Military Operating Area (MOA). To avoid an unpleasant encounter with a high-speed jet, you can look at the table in the chart's margin, partially shown in Figure 7-19, and determine that jets using this area do not operate below 8,000 feet. You can note this on the chart with a line over 8,000, which means to remain below 8,000 feet.

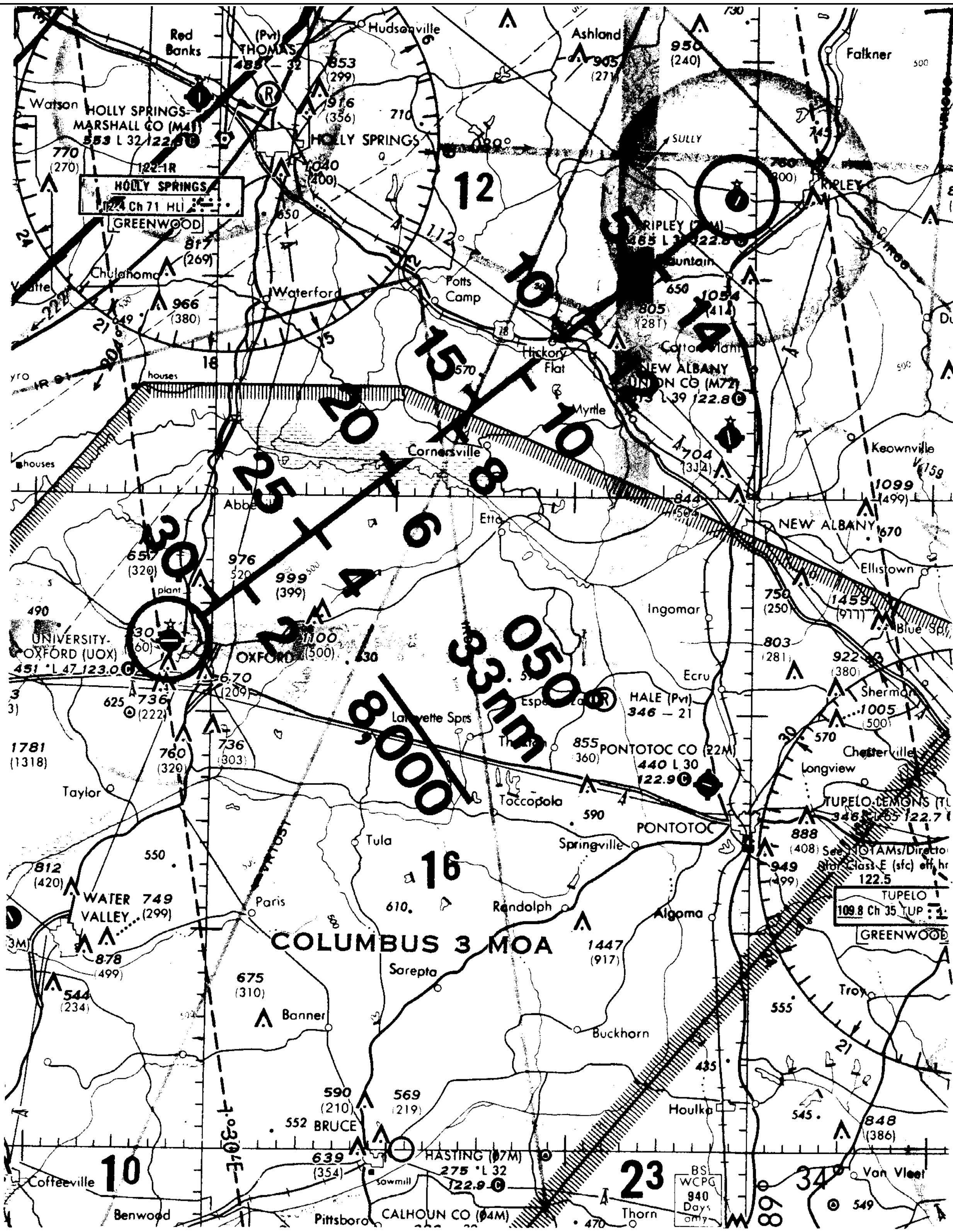

COLUMBUS 3 MOA
050
33nm
8,000
HOLLY SPRINGS
OXFORD
NEW ALBANY
PONTOTOC
RIPLEY
TUPELO
WATER VALLEY
BRUCE

Figure 7-18

Next you must determine the total distance you're going to fly. Measure this using the scale that's printed on the plotter's straight edge, making sure you use a scale appropriate to the scale of the chart. Use the 1:500,000 scale for sectionals. As an alternative, lay a paper's edge along the course line, make pencil marks on the paper's edge at the two airports, and then lay that same edge along the line of latitude. By simply counting the minute marks on the chart's latitude line that fall between those two pencil marks, you can determine the distance between the two airports in nautical miles. In the example, Oxford and Ripley are 33 nm, or 33 nautical miles, apart.

There are a number of ways you can add information to your chart that will help during the flight. Each flier has his own techniques or variations of the techniques presented here, and over time, you will develop a preference for methods that work best for you.

Tick marks along the course line at specific intervals will help you keep track of your position on the sectional during flight. Some individuals prefer five or ten nm intervals for tick marks, while others prefer two or four nm intervals. Four nautical mile spacing works well for aircraft that operate at approximately 120 knots. Since the 120-knot airplane travels two nm every minute, each four nm tick mark represents approximately two minutes of flight time. This will become more significant when you study navigational methods in later paragraphs. On the example chart, you have tick marks on the right side of the course line at four nm intervals. If the search airplane has an airspeed indicator marked in miles per hour instead of knots, it may be advantageous to space the tick marks in statute mile intervals.

On the left side of the course line you have more tick marks, at five nm intervals, but measured backward from the destination. In flight, these continuously indicate distance remaining to the destination. If your navaids are operable, particularly the GPS, these marks are not necessary. Later in this chapter you will learn how to use navaids to continuously confirm remaining distance.

The next step in preparing the chart is to identify "*checkpoints*" along the course that you can later use to check not only your position on or off course, but the timing along the leg. Prominent features that will be easily seen from the air make the best checkpoints, and many fliers like to circle them or highlight them with a marker in advance. On the example, you might expect to see the large towers east of Oxford about three nm to your right shortly after take off, and expect later to see the town of Cornersville. Shortly thereafter, you expect to see the road and railroad bend east of Hickory Flat, followed by the Ripley Airport itself. In the example, the checkpoints are widely spaced, but on actual missions checkpoint spacing will be controlled by search altitude, weather conditions and visibility at the time of the flight.

MOA NAME	ALTITUDE OF USE	TIME OF USE	CONTROLLING AGENCY
ANNE HIGH	7,000	SR - SS MON - FRI	ZFW CNTR
BIRMINGHAM	10,000	0700-2200	ZTL CNTR
COLUMBUS 1, 2, & 3	8,000	SR - SS MON - FRI	ZME CNTR
MERIDIAN 1 EAST	8,000	SR - SS MON - FRI	ZME CNTR

Altitudes indicate floor of MOA. All MOAs extend to but do not include FL180 unless otherwise indicated in tabulation or on chart.

Figure 7-19

Other information that may be written on the chart includes estimated times of arrival (ETAs) at each checkpoint and reminders like "check gas," "switch tanks," or "contact mission base." Crew members are likely to spend less time "fishing" about the cockpit trying to find information in flight if it is already written on the chart.

7.8.1 Plotting the Course

Lay the chart on a table or other flat surface, and draw a straight line from your point of departure to the destination (airport to airport). This can be done with a plain ruler or, better, with a navigation plotter. Mark off the distance in ten or 20-mile intervals. Use a sharp pencil, making sure the line is straight and that it intersects the center of the airport symbol. Make a careful study of the intervening country and decide whether to fly direct or whether a detour may be desirable in order to avoid flying over large bodies of water, mountains, or other hazardous terrain. Note whether landing fields are available enroute for refueling or use in case of an emergency. Using an appropriate groundspeed and the actual distance to destination, estimate your time enroute. You should know the range (in fuel hours) of the aircraft you intend to fly. From this you can determine whether or not you can make the flight without fueling stops. Be sure to allow at least a 30-minute fuel reserve to your destination (this reserve is increased to 45 minutes for night flight).

7.8.2 Checkpoints

Now that you have established a definite course from departure to destination, study the terrain on the chart and choose suitable checkpoints. These should be distinctive features such as railroad tracks or highways, sharp bends in rivers, race tracks, towers, quarries, or lakes. As your flight progresses, these checkpoints will be used to maintain the correct course and to estimate the groundspeed. Your checkpoints need not be on your direct line of flight, but should be near enough to be easily seen. For this part of the pre-flight planning it is essential that you know the chart symbols (explained on the back of the chart) in order to recognize the many landmarks available as checkpoints.

You need to note the identifiers (i.e., airports, VORs, or airway intersections) along or near the route for entry into the GPS. If none (or not enough) are available, determine the latitude and longitude of suitable points along the route. The identifiers and lat/long points are used to enter a flight plan into the GPS and also serve as checkpoints that can be verified using the GPS during the flight.

7.8.3 Enclosing the Course

Another method you may use if your GPS is not operable is enclosing the course. This consists of using an easily recognizable feature on the terrain that lies parallel to your course. It may serve as a guideline or bracket, and may be a river, railroad track, electrical distribution lines, or a prominent highway. The ideal arrangement would be to have a continuous guideline on each side of the route, say five to ten miles from the line of flight. It is seldom that two can be found, but one will usually serve. If you should temporarily lose your checkpoints, you can fly to this chosen guideline and reset your course. Another landmark should be used as an end-of-course checkpoint to prevent flying beyond your destination.

7.8.4 True Course

Having plotted your course and made an accurate listing of checkpoints and the distances between them, measure the true course counting clockwise from true north. Use the meridian (north-south) line approximately midway between departure and destination. Your true course can be measured with a common protractor, or better still with a navigation plotter.

Without a GPS it's not likely that your aircraft will easily follow the precise true course between departure point and destination. Magnetic variation, wind and compass deviation affect the aircraft’s ground track. The following sections discuss these factors and what the aircrew can do to counteract them if the GPS is not operable.

7.8.5 Applying Variation to True Course

The magnetic compasses used in aircraft refer all directions to magnetic north rather than to true north, which is the reference for directional measurement on the chart. At most places in the world, magnetic and true north do not coincide. This difference between magnetic variation at any locality is shown on all aeronautical charts by means of lines of equal variation known as isogonic lines. In the northeastern U. S. the variation is westerly (that is, the magnetic compass points west of true north) and the rest of the country is easterly (that is, the magnetic compass points east of true north). The dividing line between easterly and westerly variation is the agonic line, or line of no variation, where magnetic north and true north are the same.

Since we measure courses from a chart with reference to true north and then try to fly this course by means of a magnetic compass, it is necessary to apply the variation to the true course to determine magnetic course. To convert a true course to magnetic course, always add westerly variation and subtract easterly variation.

For example, say you plan to fly from Airport A to Airport B. The true course is 130°. The variation as shown on the chart by the nearest isogonic line is 12° east (12° E). Applying the rule of subtracting easterly variation and adding westerly variation, the magnetic course is 130° - 12° = 118°.

7.8.6 Applying wind correction

Assume that you have climbed to cruising altitude and arrived over your first checkpoint. Between this checkpoint and the second one, you should make allowance for the approximate drift of your aircraft due to the effect of the wind. In pilotage, correction for wind drift is made by noting whether or not your plane is drifting to the right or left of your intended true course. Should you note a right drift it will be necessary to correct to the left. The amount of correction will be determined by the amount of observed drift and where you actually are in relation to your intended course. If you note an approximate 10-degree leftward drift after passing over your first checkpoint, it will be necessary to correct 10 degrees to the right in order to remain on course. Drift of the airplane can be observed if you note landmarks such as a highway, railroad, or section lines approximately parallel to your course. In flying one of these lines the plane's drift to right or left can be approximated.

It is important that between the first and second checkpoints you have noted the reading on your compass. The compass (assuming no instrument error) should now read the sum of your true course, plus or minus variation, and plus or minus your wind correction angle. This is the magnetic heading, and should be maintained on your compass from one checkpoint to another so long as you remain on course.

In the example problem stated above, the computations for magnetic heading should be:

- True course (TC) = 130°
- Magnetic variation (VAR) = 12° E
- Magnetic course (MC) = 118°
- Wind correction angle (WCA) = 10° R
- Magnetic heading (MH) = 128°

Thus you have a magnetic heading from first to second checkpoint. You would hold this magnetic heading of 128 so long as you remain on course toward the next checkpoint.

If your calculations are correct, your estimate of the drift angle is close enough, and you hold the magnetic heading of 128 degrees, then you will actually make good the true course of 130 degrees between Airport A and Airport B. Remember that in correcting your compass for variation and wind effect, you are simply setting up a compass reading calculated to keep you on your intended true course.

7.8.7 Compass Deviation

Compass deviation is technically defined as the angle between the magnetic meridian and the axis of a compass card, expressed in degrees east or west (in the same way that variation is) to indicate the direction in which the northern end of the compass is offset from magnetic north. Less technically, deviation is compass error. It is caused by a number of things, but mostly by instruments and equipment within the aircraft itself - metal parts of the aircraft structure, flashlights, cockpit heaters, electrical circuits, radios, metal tools, cigarette lighters. Even a Boy Scout's pocket compass, when placed close enough, can throw an aircraft compass off as much as 50 degrees. The point is, however, that the error in a compass caused by the permanent equipment in an aircraft is not important if the amount of error is known. Some error can be removed by qualified instrument mechanics adjusting the compass magnets. This is called compass compensation. To determine the amount of error left after compensation, the compass can be "swung."

The aircraft is placed in straight and level flight attitude in the center of a large circle oriented exactly to magnetic north and usually painted on the ramp or parking apron of an airport. Sometimes the aircraft engine is started up and the radio equipment is turned on to simulate as closely as possible actual flight conditions. The aircraft is then turned within the circle until it is aligned with magnetic north, and the difference between the reading of the aircraft compass and magnetic is the deviation for that heading. The process is repeated every 30 degrees around the compass rose. A record of the deviation is made on each of the 12 headings, and is then entered on a compass correction card that is placed near the compass installation in the cockpit for the pilot's reference.

7.9 Navigational Methods

With the advent of GPS, most VFR navigation is simply a matter of entering your waypoint and/or destination into the GPS and flying the displayed heading. However, other methods of navigation will be reviewed before we discuss how to use the GPS for navigation.

7.9.1 Dead Reckoning and Pilotage

The most commonly used methods of navigating without using navaids are *pilotage*, *dead reckoning*, and a combination of both. This section will cover the advantages and disadvantages of each.

Pilotage is nothing more than basic map reading, proceeding from one prominent landmark to another. You could conceivably use pilotage to navigate from New York City all the way to Miami if you were to simply fly to the coast, turn right, and then follow the shoreline, while periodically checking your position against prominent coastal features and cities. Given a chart with sufficient detail, you can do the same with smaller features and landmarks. Its greatest disadvantage is that there may not always be prominent landmarks directly in line with the direction you wish to fly. On the hypothetical Oxford-to-Ripley flight, there aren't many landmarks nearby in the first ten miles. If the visibility is good, you might see the 999' and 1100' towers east of Oxford to your right, but initially not much more, especially if you're at low altitude.

Dead reckoning is a technique of using speed and time to calculate distance, and then plotting the calculated distance in the direction the aircraft has been traveling. The process is frequently referred to as *time, distance, and heading*. As an example of dead reckoning, if you take off from Oxford and fly a 050° magnetic heading for 16 1/2 minutes at 120 knots, and then look down, you would be over or very near the Ripley Airport. Dead reckoning becomes more complicated when wind is present, and *by itself* usually does not render the level of accuracy required to fly precise search patterns.

Most experienced aviators continuously use a combination of pilotage and dead reckoning when visually navigating, alternating from one to the other so frequently that it appears to be a singular process, not an actual choice of alternatives. For flight segments that don't have a wealth of landmarks, like northeast of Oxford, dead reckoning helps estimate aircraft position, until you can confirm it (through pilotage) at or near a landmark. In this sense, you use pilotage to verify the dead reckoning, but the reverse can be true. Again, proceeding 050° from Oxford, if you pass a town approximately 8 minutes after take off, is it Cornersville or Hickory Flat? On the chart, both towns appear similar, and they're along hard-surfaced roads that generally run northwest to southeast. Since you've only been airborne for 8 minutes, and you're flying at 120 knots, the town *can't* be Hickory Flat which is 23 miles away. The plane would have to fly nearly three miles a minute or almost 180 knots to fly 23 miles in eight minutes.

Good pilotage also has the capability to improve your dead reckoning by indirectly providing you with more accurate information. Returning to the example, if you pass Cornersville 10 minutes after take off instead of 8 minutes as planned, the average ground speed for those 10 minutes is 102 knots, not the 120 knots you had planned. Thus, you should not expect to pass Hickory Flat, 6 1/2 miles further, for another 4 minutes, and will not arrive at Ripley until 19 minutes after take off, not 16 minutes as you had originally planned. You could rightfully estimate an approximate 18-knot headwind en route to Ripley and might expect an 18-knot tailwind, a 138-knot ground speed, and a 14-minute en route time for the opposite-direction flight back to Oxford.

Pilotage in its simplest form is a means of navigating from one point to another by visual reference to landmarks or checkpoints on the ground. These may be railroad tracks, highways, cities, towns, rivers, mountains, shorelines, dams, racetracks, or any of the scores of other prominent features on the earth's surface which can be seen and identified from the air. All that's required for this basic kind of navigation is good visibility, an up-to-date chart, and an ability to organize your procedures in a systematic way. It sounds easy, and it actually is -- if you don't try to fly in doubtful weather and if you plan your flight.

Experienced pilots place a lot of emphasis on pre-takeoff planning for a cross-country flight. Planning is, in fact, an integral part of cross-country flying.

7.9.2 Low Level Flying

The closer to the ground you are, the less time you have to observe landmarks and make visual observations. Remember also that as you get closer to the ground, you have less time to see and avoid obstructions and hazards. You should study the map of the area you will encounter in great detail so that you know what ground references, obstructions and hazards to expect and so that you will be able to quickly identify them in flight. Crew coordination will be essential at low levels, so ask questions during the aircrew briefing. Finally, due to the increased concentration and quicker pace of low-level flying, you will find that fatigue sets in more quickly -- so plan accordingly.

7.9.3 GPS Navigation

The advent of the Global Positioning System (GPS) and its incorporation into CAP aircraft panels marks a significant improvement in the ease and accuracy of navigation. GPS allows us to fly much more precisely than in the past, thus increasing safety and fuel efficiency.

The GPS is a space-based radio positioning, navigation and time-transfer system based upon accurate and continuous knowledge of the spatial position of each satellite in the system with respect to time and distance from a GPS receiver. The GPS receiver automatically selects appropriate signals from the satellites in view and translates these into a three-dimensional display of position, velocity and time. System accuracy for civilian (and CAP) users is normally 100 meters horizontally.

7.9.3.1 How does GPS make navigation easier?

GPS allows us to fly to a point, or between any two points, with incredible ease and accuracy. It enables us to know precisely where we are at all times. Therefore, both the crew and the mission staff know that transit times will be minimized, search times will be maximized, search effectiveness will be increased, crew efficiency will be increased, fuel efficiency will be increased, and flight safety will be enhanced.

The benefits of being able to plan and fly directly to and from a point, and to precisely fly between any two points without reference to landmarks, are obvious. Transit times go down, routes are flown as they are planned, obstructions and hazardous terrain can be avoided, airspace “busts” can be avoided, and the aircrew spends less time scouring charts and ground references to determine aircraft position.

Additionally, the ability to be certain that a crew is flying the route as planned increases safety when more than one aircraft is in route to the search area at the same time.

7.9.3.2 How do we use GPS for navigation?

The database in the GPS receiver contains the locations of every public-use and military airport, VOR, and airway intersection in the United States. Any of these airports, VORs, and intersections can be selected as a destination or as a waypoint on a flight plan. If you aren't flying to an airport or VOR, you can define your own waypoint and enter it into the database.

Since GPS manufacturers differ somewhat in the way information is entered and displayed on their units, we won't go into detail on how to enter or display information. However, since all GPS units have essentially the same capabilities and displays, we can provide a generic description of the GPS. Each of you must study your aircraft's GPS manual and become thoroughly familiar with its capabilities and operation.

In order to fly directly to a point you must enter its identifier (e.g., 'AMA' for Amarillo International Airport or 'PNH' for the Panhandle VORTAC, for a flight to Amarillo, Texas). The GPS requires you to select whether the point is an airport, a VOR, an airway intersection, or a user-defined waypoint and then you manually enter its name and select it. The GPS then displays data pertinent to the destination or waypoint.

If you're not flying to an airport, VOR, or airway intersection you can define your own waypoint, called a "user-defined" waypoint. You enter the latitude and longitude of the waypoint and give it a name. You then select it as described above. Most GPS databases allow you to store 300 or more of these user-defined waypoints, and they remain in the database until you delete them.

The GPS navigation page will display the heading to your destination or waypoint along with the aircraft's track over the ground. By keeping track-over-ground the same as the heading, you will be correcting for any wind and be flying directly to your destination or waypoint. The GPS also displays a Course Deviation Indicator (CDI) on the same page, and by keeping the CDI centered you will be flying directly to your destination.

The GPS continuously updates the distance from and the time remaining to your destination or waypoint (ETE). It also tracks the airports and VORs nearest to your route (usually ten or more within 50 nm). These airports and VORs can be displayed at the touch of a button.

Another mode of the GPS, usually called the Auxiliary mode, displays and continuously updates your current position in terms of latitude and longitude. This feature is particularly useful in flying search patterns (discussed later), and provides another means for you to determine where you are on a sectional or other map. It is also useful in reporting your position to mission base or ground units.

The GPS also enables you to enter a flight plan. You enter each waypoint (leg) in its proper sequence, name the flight plan, and then activate it at the beginning of your flight. The GPS automatically displays the current leg, rolls over to the next leg when a waypoint is reached, and continues in this manner until you reach your final destination.

Most GPS units also warn you when you near controlled and special use airspace.

All these features greatly enhance situational awareness and safety, especially for night flights. You can always find your present position, and in case of trouble you can select the nearest airport and the GPS will display heading and distance to that airport.

As an observer, you should be able to:

assist the pilot in planning a flight where GPS will be used for navigation.

select/display an airport, VOR, or intersection.

enter a user-defined waypoint (lat/long), name it, and select it.

select/display present position (lat/long).

display the nearest airports, and determine their heading and distance.

display the nearest VORs, and determine their heading and distance.

use GPS displays to determine your position on a sectional or other map.

NOTE:

However convenient and accurate, you cannot let GPS become your sole means of navigation and situational awareness! The GPS will not automatically guide you around or over obstructions and other hazards. You still need to thoroughly plan your flight and then periodically verify your position using other navaids (e.g., VOR and DME). You still need to track your position on the sectional.

Although GPS displays altitude, it is subject to error. The altimeter is your primary instrument for altitude.

Also, remember that CAP does not have IFR-certified GPS units. Our GPS units cannot be used for GPS instrument approaches.

7.10 Standardized Grid Systems

A grid is a network of regularly spaced horizontal and vertical lines used to help quickly locate points on a map. Most city street maps have grid systems that help motorists locate streets or other points of interest. A commonly used grid system on city street maps involves numerical and alphabetical references. Regularly spaced letters may be printed across the top of such a map designating imaginary vertical columns, while regularly spaced numbers are printed down the sides of the map designating imaginary horizontal rows. If you want to find Maple Street and the map directory indicates Maple Street is located in section K-5, you then look at or near the intersection of column K with row 5. Within that area, you should find Maple Street.

The Civil Air Patrol has found it useful to construct similar grid systems on aeronautical charts for search and rescue operations. Some maps, like city maps, already have grid systems constructed on them, but aeronautical charts typically do not. You can construct a grid system on any type of chart or map. You may use numbers and letters like street maps, or you could use only numbers. In either case, the system should give *every* user a common, standardized method for identifying a location according to its position within the grid. It is very easy to exchange location information over the radio using the grid system. With the known grid positions, other team members can quickly determine on their own charts the location of a sighting or point of interest.

Grid systems are especially helpful when locating a position that has no nearby distinguishable landmarks or features, such as buildings, roads, or lakes. Grid systems will work anywhere, even in the middle of large lakes, in deep woods, or in swamps.

Anyone can develop a workable system provided that all members of the search team use the same grid system.

7.10.1 Sectional Chart Grids

The Civil Air Patrol has adopted a standard grid system built upon the matrix of parallels of latitude and meridians of longitude and the sectional aeronautical chart. Sectional charts cover a land area approximately seven degrees of longitude in width and four degrees of latitude in height. Figure 7-20 shows the latitude and longitude boundaries of each sectional chart. The St. Louis chart, for example, covers an area that is bounded by the following latitudes and longitudes: 40° 00' N (north boundary), 36° 00' N (south boundary), 91°-00' W (west boundary), and 84°-00' W (east boundary).

The sectional grid system used by Civil Air Patrol divides each sectional's area into 448 smaller squares. This process begins by dividing the whole area into 28 *1-degree* grids, using whole degrees of latitude and longitude as shown in Figure 7-21. Then each one-degree grid is divided into four 30-minute grids, using the 30-minute latitude and longitude lines as shown in Figure 7-22. Finally, each of the 30-minute grids is divided into four *15-minute* grids (the standard), using the 15- and 45-minute latitude and longitude lines as shown in Figure 7-23.

Chart	Identifier	North Grid Limit	South Grid Limit	West Grid Limit	East Grid Limit	Total Grids
Seattle	SEA	49-00N	44-30N	125-00W	117.00W	576
Great Falls	GTF	49-00N	44-30N	117-00W	109-00W	576
Billings	BIL	49-00N	44-30N	109-00W	101-00W	576
Twin Cities	MSP	49-00N	44-30N	101-00W	93-00W	576
Green Bay	GRB	48-15N	44-00N	93-00W	85-00W	544
Lake Huron	LHN	48-00N	44-00N	85-00W	77-00W	512
Montreal	MON	48-00N	44-00N	77-00W	69-00W	512
Halifax	HFX	48-00N	44-00N	69-00W	61-00W	512

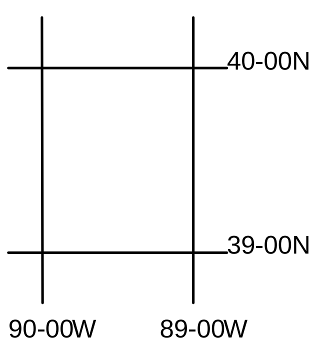


Figure 7-21

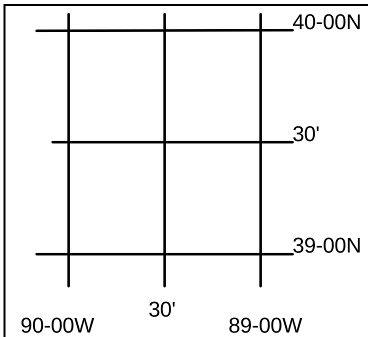


Figure 7-22

Klamath Falls	LMT	44-30N	40-00N	125-00W	117-00W	576
Salt Lake City	SLC	44-30N	40-00N	117-00W	109-00W	576
Cheyenne	CYS	44-30N	40-00N	109-00W	101-00W	576
Omaha	OMA	44-30N	40-00N	101-00W	93-00W	576
Chicago	ORD	44-00N	40-00N	93-00W	85-00W	512
Detroit	DET	44-00N	40-00N	85-00W	77-00W	512
New York	NYC	44-00N	40-00N	77-00W	69-00W	512
San Francisco	SFO	40-00N	36-00N	125-00W	118-00W	448
Las Vegas	LAS	40-00N	35-45N	118-00W	111-00W	476
Denver	DEN	40-00N	35-45N	111-00W	104-00W	476
Wichita	ICT	40-00N	36-00N	104-00W	97-00W	448
Kansas City	MKC	40-00N	36-00N	97-00W	90-00W	448
St. Louis	STL	40-00N	36-00N	91-00W	84-00W	448
Cincinnati	CVG	40-00N	36-00N	85-00W	78-00W	448
Washington	DCA	40-00N	36-00N	79-00W	72-00W	448
Los Angeles	LAX	36-00N	32-00N	121-30W	115-00W	416
Phoenix	PHX	35-45N	31-15N	116-00W	109-00W	504
Albuquerque	ABQ	36-00N	32-00N	109-00W	102-00W	448
Dallas-Fort Worth	DFW	36-00N	32-00N	102-00W	95-00W	448
Memphis	MEM	36-00N	32-00N	95-00W	88-00W	448
Atlanta	ATL	36-00N	32-00N	88-00W	81-00W	448
Charlotte	CLT	36-00N	32-00N	81-00W	75-00W	384
El Paso	ELP	32-00N	28-00N	109-00N	103-00W	384
San Antonio	SAT	32-00N	28-00N	103-00W	97-00W	384
Houston	HOU	32-00N	28-00N	97-00W	91-00W	384
New Orleans	MSY	32-00N	28-00N	91-00W	85-00W	384
Jacksonville	JAX	32-00N	28-00N	85-00W	79-00W	384
Brownsville	BRO	28-00N	24-00N	103-00W	97-00W	384
Miami	MIA	28-00N	24-00N	83-00W	77-00W	384

Figure 7-20

Next, the grid squares are numbered 1 through 448, beginning usually with the most northwest square on the entire sectional and continuing straight east through number 28. The numbering resumes in the second row, with number 29 placed beneath number 1, 30 beneath 2, and so on through 56. The third row begins with number 57 beneath numbers 1 and 29, and continues through 84. Numbering continues through successive rows until all 448 squares have a number.

In Figure 7-23, each 15-minute grid square has the number it would have received if this demonstration had started with the entire St. Louis sectional chart. Figure 7-24 represents the division of the whole St. Louis sectional into 15-minute grids, with respective grid numbers assigned. To conserve space Figure 7-24 doesn't include the area between 85°W longitude and 89°30'W longitude

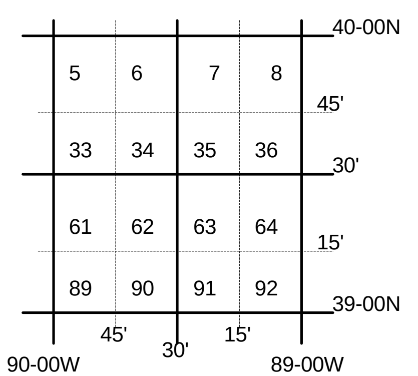


Figure 7-23

Returning to Figure 7-20, notice that the eastern limit of the Kansas City sectional grid, 90° 00'W, is one full degree of longitude east of the western limit of the St. Louis sectional, 91° 00' W. The two sectionals overlap by one full degree of longitude. When drawing a grid over this overlap area, which numbers would you assign to these grid squares, the Kansas City or St. Louis grid numbering?

40-00N	91-00W					90-00W				85-00W		
	MKC 25	MKC 26	MKC 27	MKC 28	STL 5	STL 6	< >	< >	STL 25	STL 26	STL 27	STL 28
	MKC 53	MKC 54	MKC 55	MKC 56	STL 33	STL 34	< >	< >	STL 53	STL 54	STL 55	STL 56
	MKC 81	MKC 82	MKC 83	MKC 84	STL 61	STL 62	< >	< >	STL 81	STL 82	STL 83	STL 84
39-00N	MKC 109	MKC 110	MKC 111	MKC 112	STL 89	STL 90	< >	< >	STL 109	STL 110	STL 111	STL 112
	MKC 137	MKC 138	MKC 139	MKC 140	STL 117	STL 118	< >	< >	STL 137	STL 138	STL 139	STL 140
	MKC 165	MKC 166	MKC 167	MKC 168	STL 145	STL 146	< >	< >	STL 165	STL 166	STL 167	STL 168
	MKC 193	MKC 194	MKC 195	MKC 196	STL 173	STL 174	< >	< >	STL 193>	STL 194	STL 195	STL 196
38-00N	MKC 221	MKC 222	MKC 223	MKC 224	STL 201	STL 202	< >	< >	STL 221	STL 222	STL 223	STL 224
	MKC 249	MKC 250	MKC 251	MKC 252	STL 229	STL 230	< >	< >	STL 249	STL 250	STL 251	STL 252
	MKC 277	MKC 278	MKC 279	MKC 280	STL 257	STL 258	< >	< >	STL 277	STL 278	STL 279	STL 280
	MKC 305	MKC 306	MKC 307	MKC 308	STL 285	STL 286	< >	< >	STL 305	STL 306	STL 307	STL 308
37-00N	MKC 333	MKC 334	MKC 335	MKC 336	STL 313	STL 314	< >	< >	STL 333	STL 333	STL 334	STL 336

Figure 7-24

In cases where two sectionals overlap one another, the Civil Air Patrol always uses the numbering system for the western-most chart of the two in question. You can see this in Figure 7-24, where the overlap area between 90° 00' and 91° 00', shown in the first 4 vertical columns, is identified with Kansas City (MKC) grid numbering, not St. Louis. Note too that, since the Kansas City grid numbering is used in this overlap area, the first 4 columns of the St. Louis grid numbering system are omitted. Several other such overlaps exist within the grid system.

Table A-15-1 in CAPM 50-15 tells you how many grids are in each sectional. If the table is not available you can compute it using the grid limits. Take the difference in the northern and southern grid limits and multiply by 4 (1/4 degree x 4 to make 1 degree.) Do the same for the east and west grid limits. Then multiply the two products to get the total number of grids on your sectional. For example, the St. Louis sectional extends 4° from 40°-00' N to 36°-00' N. Each degree will contain 4 grids, so there will be 4 x 4 = 16 rows of grids. The sectional extends east/west for 7° from 91°-00' W - 84°-00' W, so there will be 7 x 4 = 28 columns of grids. Therefore, the total number of grids on the chart is 16 x 28 = 448. Remember some sectionals don't start counting at 1 because of overlap with an adjacent sectional. If your sectional does this you need to memorize the first grid number:

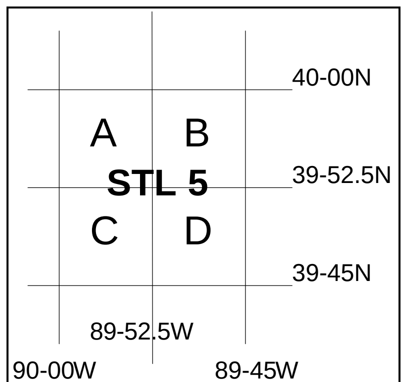


Figure 7-25

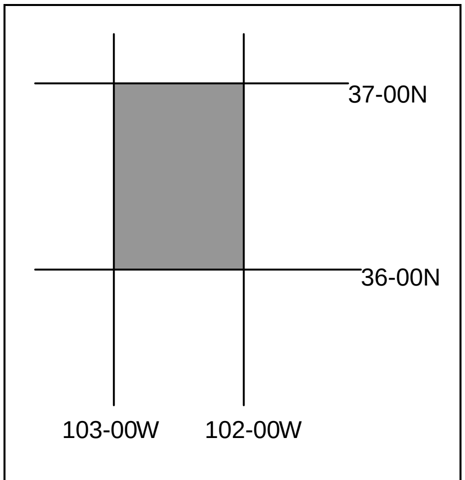


Figure 7-26

When circumstances require, a 15-minute grid is divided into four quadrants using 7 1/2 degree increments of latitude and longitude, creating four equal size grids that are approximately 7 1/2 miles square. The quadrants are then identify alphabetically - A through D - starting with the northwest quadrant as A, northeast as B, southwest as C and southeast as D, as in Figure 7-25. A search area assignment in the southeast quadrant may then be made as, "Search STL 5D."

Pinpointing an area within the grid system becomes easy once you gain familiarity with the grids many uses. You soon will be able to quickly plot any area on a map and then fly to it using the basic navigation techniques already discussed.

7.11 Standardized Lat/Long Grid System

Another means of designating a grid system is the Standardized Latitude and Longitude Grid System. It has an advantage over the sectional standardized grid in that it can be used on any kind of chart that has lines of latitude and longitude already marked. In this system, 1-degree blocks are identified by the intersection of whole numbers of latitude and longitude, such as N36-00 and W102-00. These points are always designated with the latitude first, such as 36/102, and they identify the area north and west of the intersection of these two lines. In Figure 7-26, section 36/102 is identified by the gray shading.

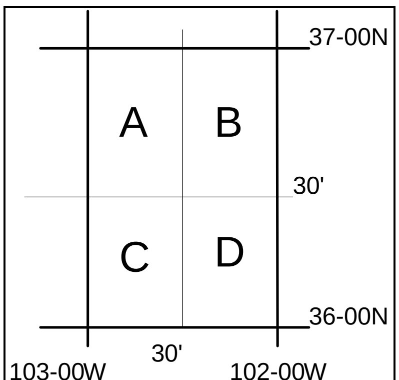


Figure 7-27

Next, the one-degree grid is divided into four quadrants using the 30-minute lines of latitude and longitude. Label each quadrant A through D; the northwest quadrant being 36/102A, the northeast 36/102B, the southwest 36/102C, and the southeast 36/102D, as shown in Figure 7-27. Each quadrant can also be divided into four sub-quadrants, labeled AA, AB, AC, and AD, again starting with the most northwest and proceeding clockwise, as shown in Figure 7-28. This grid system works on any chart that has latitudes and longitudes printed on it.

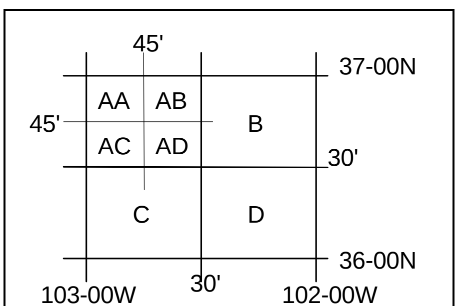


Figure 7-28

8. Flight computer

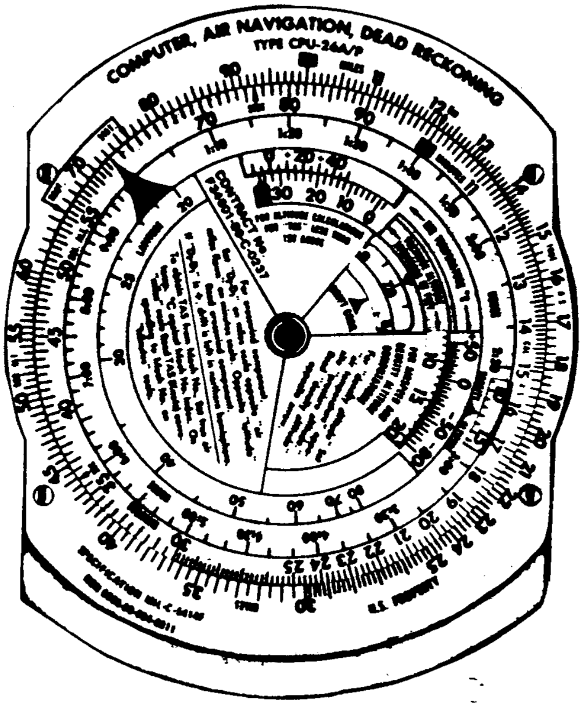


Figure 8-1

This chapter will briefly introduce the operation of the “slide rule” face of the flight computer, known by many fliers as the “whiz wheel”. It’s a time-proven tool that has a variety of uses. Some pilots prefer special electronic calculators that can accomplish the same functions as whiz wheels, but others prefer the wheel’s simplicity.

The flight computer’s primary advantage is that it’s not dependent upon any source of electrical power, like battery- or solar-powered calculators. It can be used at night, on cloudy days, or bright sunny days with equal accuracy. Its primary disadvantage is that the user must mentally keep track of the decimal point. It’s not uncommon for the new user to calculate wrong by a factor of 10. But, with experience such errors become less common. The whole slide rule face is pictured in Figure 8-1. The wind face of the computer is on the other side and will not be covered in this text.

The computer side of the flight computer has 3 concentric scales that go all the way around the wheel. The outside one is on the stationary part, and the other two are on the rotating wheel. For sake of this discussion, the scales will be referred to as the outer, middle and inner scales. It also includes a number of other features including an assortment of windows and indexes. The most important other feature is the large triangle-shaped *rate index*. Refer to Figure 8-2 and locate the 3 scales and the rate index.

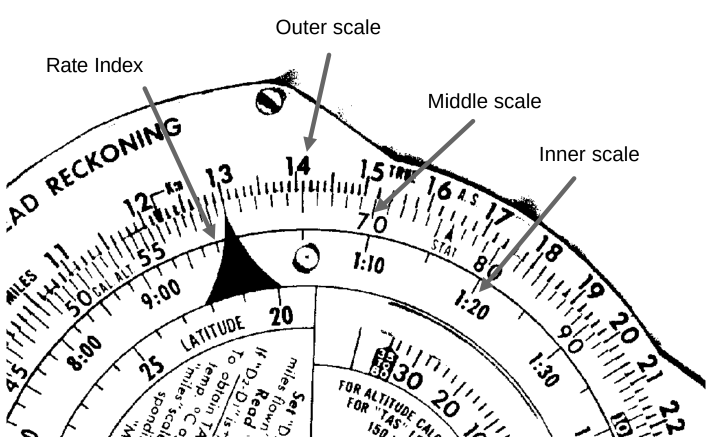


Figure 8-2

The other side of the computer is referred to as the “wind face.” There is a rotating part with a plastic window, a scale on the fixed frame along with the true index, and a sliding panel with curved lines.

The flight computer is most commonly used to solve rate problems. In its simplest form a rate problem consists of three variables—rate, time, and units. The “units” may be anything that you work with over a period of time, but the most common in aviation are miles of distance and gallons of gasoline. The “units” part

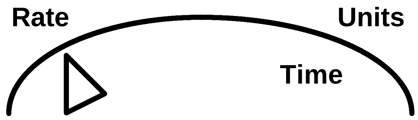


Figure 8-3

of the problem may be expressed in any measurement as long as the “rate” portion is expressed in the same units. For instance, if you are solving a problem involving nautical miles, the rate must be expressed in terms of nautical miles per hour or knots. The rate must be expressed in units/hour, and the time must be expressed in minutes to use the middle scale.

All rate problems are set up on the flight computer as seen in Figure 8-3. The rate on the outer scale is matched with the rate index on the middle scale, and the units on the outer scale are matched with the time on the middle scale. Just rotate the moveable wheel and use the two known variables to find the third one. Here’s some examples using miles, miles-per-hour (mph), and time:

8.1 Speed

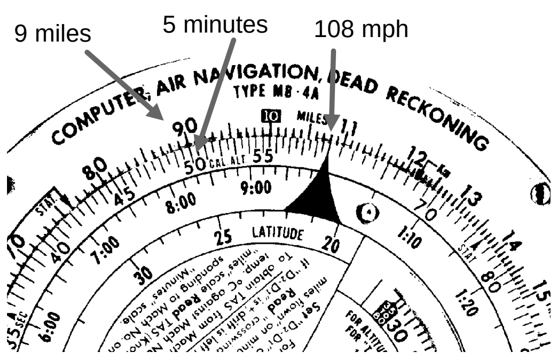


Figure 8-4

You flew the first nine miles of a trip in five minutes. What is your average ground speed?

Study Figure 8-4 for the solution to this problem. Rotate the inner disk until five minutes (on the middle scale) is directly beneath nine miles (on the outer scale). Then look to the number on the outer scale directly opposite the triangular rate index. You can see that the index points to the eighth line between ten and eleven. What number does this represent? As stated earlier, the wheel’s primary disadvantage is that the user has to mentally keep track of the decimal point position. In this problem, if you had flown ten miles in five minutes, your ground speed would be exactly two miles per minute or 120 mph. You didn’t quite fly ten miles, but your answer should be close to 120 knots. The eighth line between ten and eleven in this problem thus equals 108 knots.

8.2 Time

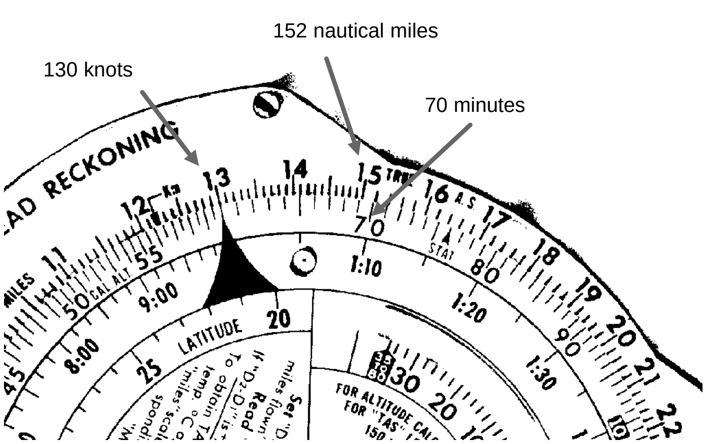


Figure 8-5

During flight planning, you calculate a ground speed of 130 knots. How long will it take you to fly 152 miles at that speed?

This is similar to the last problem except it’s worked in reverse. Start by lining up the rate index (on the movable disk) with 130 on the miles scale as shown in Figure 8-5. Then look along the outer scale (representing miles) until you find the distance you plan to fly -- 152 miles. Directly under 152 is the answer, 70 minutes.

Notice that immediately beneath 70 on the middle scale is 1:10 on the inner scale. The computer's designer included this feature to help the user convert minutes into hours and minutes. In this problem, the solution is apparent -- 70 minutes equals one hour and ten minutes. When dealing with larger numbers, the solutions are not so apparent, and you'll appreciate the convenience of this extra scale.

8.3 Distance

On the same flight with a ground speed of 130 mph, how far can you fly in one hour and 30 minutes? With the rate index still set on 130 mph, locate one hour and 30 minutes on the inner scale and you will find that corresponds to 90 minutes on the middle scale (Figure 8-5). Now read the answer of 195 miles on the outer scale just above 90 minutes.

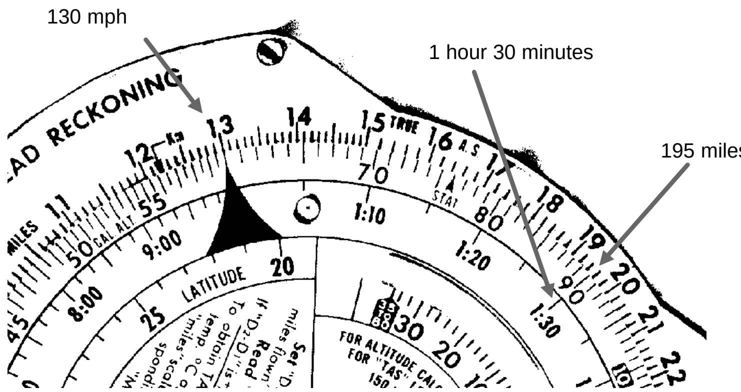


Figure 8-5

All three of the problems just covered were set up on the computer in the same way using rate, miles and time. The only difference is that you have to work with the two known variables to obtain the third one.

8.4 Scales

Now that you have tried a couple of problems, you've probably noticed something about the computer that can be very confusing – the marks on the scales do not always represent one mile or minute. Depending on where you are on the scale, a mark may represent 1, 2, 5 or even more. The best way to read a number on a scale is to refer to the nearest labeled marks and determine what each mark

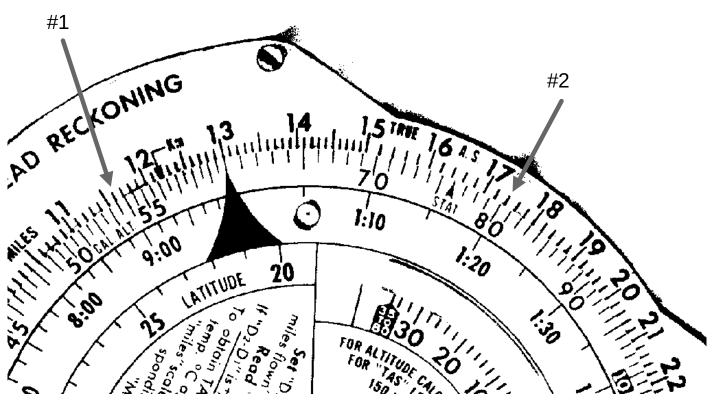


Figure 8-6

represents before deciding on the answer. For example, #1 in Figure 8-6 is pointing to 116 (or 11.6 or 1.16, etc.). When reading this number, you should look at eleven on the left, and 12 on the right. Then, you can see that each mark represents “1” and determine that the answer is 116. On the other hand, even though #2 in the same figure points to two marks right of 17, it is ***not*** pointing to 172. Look at 17 on the left and 18 on the right, and you will see that each tick mark represents “2” and the answer is 174. Other than misplacing the decimal, determining the correct units before reading an answer is the greatest source of error in using the flight computer.

8.5 Fuel

During mission planning, you determine from the airplane operating handbook that you will use 9.6 gallons of fuel each hour. How much fuel will you use on a mission expected to take six hours and ten minutes?

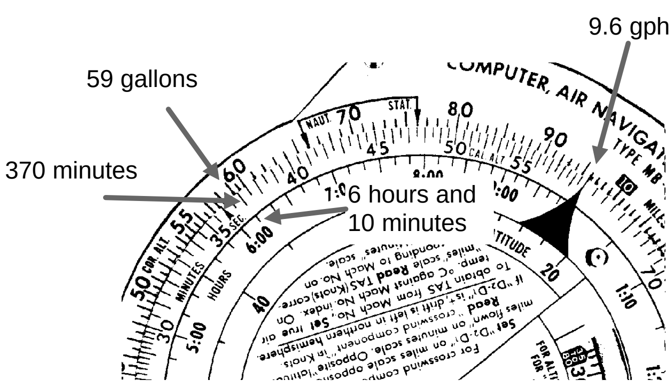


Figure 8-7

To solve this problem, the outer scale is still used to represent units, but it is gallons instead of miles. Start by lining up the rate index with the 9.6 gallon-per-hour fuel burn rate as shown in Figure 8-7. Find the time of 370 minutes on the middle scale and read the answer of 59 gallons on the outer scale. This is a good opportunity to use the inner scale to convert from hours and minutes to minutes. Six hours and 10 minutes is located on the inner scale next to 370 minutes on the middle scale. Look on the middle scale to the left of the number opposite 370 minutes (or 6:10 on the hours and minutes scale) and find the solution of slightly over 59 gallons.

8.6 Nautical and statue miles

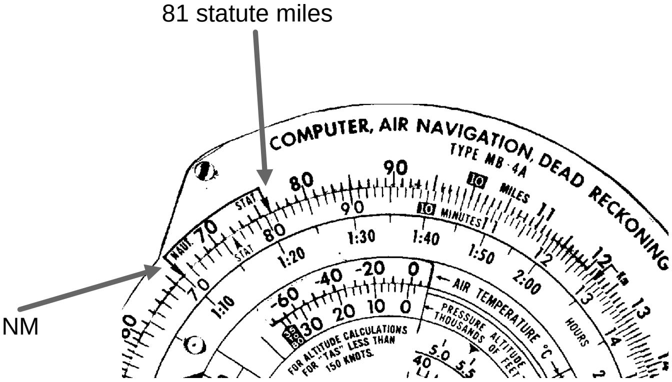


Figure 8-8

You can also use the flight computer to convert back and forth between nautical miles and statute miles. There are two connected arrows on either side of the “70” on the outer scale. The arrow on the left is labeled “NAUT” for nautical, and the arrow on the right is labeled “STAT” for statute. To convert from nautical to statute, place the nautical miles under the “NAUT” arrow and read the answer under the “STAT” arrow. To convert from statute to nautical, place the statute miles under the “STAT” arrow and read the answer under the “NAUT” arrow. Figure 8-8 shows that 70 nautical miles equals about 81 statute miles. This also works with speeds—70 knots is approximately equal to 81 miles per hour.

8.7 True airspeed

Airspeed indicators measure how fast the aircraft is moving through the air, and they are very accurate at low altitudes. However, at higher altitudes, there can be a significant difference between indicated airspeed (the number on the instrument) and true airspeed. You can use the flight computer to correct for this error. An airspeed indicator may be affected by the way it is installed in an aircraft, but that error is usually very small. Adjusting indicated airspeed for installation error yields calibrated airspeed. The difference is usually so small that calibrated airspeed is considered equal to indicated airspeed. But, to get from calibrated to true airspeed, the flight computer is used to make adjustments for altitude and temperature. For example, if you are flying at 12,000 feet where the temperature is -10° C with a calibrated airspeed of 145 mph, your true airspeed would be 173 mph. Figure 8-9 shows how to line up the altitude and temperature in the inner window, then read the true airspeed on the

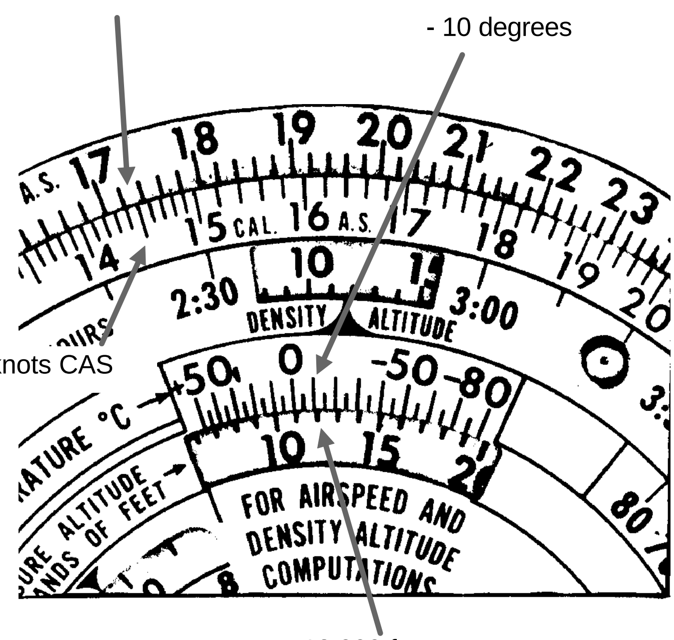


Figure 8-9

outer scale opposite the calibrated airspeed on the middle scale. On the temperature scale, notice the location of +50 and -50. That scale is reversed, so make sure you are on the correct side of zero when lining up the temperature and altitude.

8.8 The wind face

8.8.1 Frame and Compass Rose

The other side of the flight computer is primarily used to solve problems concerning wind. The frame has a reference mark called the TRUE INDEX and a drift correction scale on each side of the true index. The transparent disc, with the compass rose, rotates so you can set any direction under the true index. The center of the transparent disc has a small black circle called the GROMMET.

8.8.2 The Slide

Each side (low speed, high speed) of the slide has a portion of a circular graph printed on it. The values of each circle vary with the side. The low speed side of the slide is marked from 0 to 275, while the high-speed side is marked from 60 to 840. When the slide is inserted in the frame, the centerline lies beneath the true index and the grommet. There are lines on each side of the centerline, which radiate from the origin of the circular graph (off the slide on the high-speed side). On the low speed side, these lines are spaced at five degrees up to the 30-unit circle, at two degrees up to the 150-unit circle and at one degree the remainder of the slide.

If you picture the wind triangle superimposed upon the computer slide, it will enhance your understanding of the mechanical solutions you perform on the wind face of the computer. Notice that the arcs represent speed and the radiating lines represent drift correction. Consequently, by adding or subtracting drift correction -- the angle between the ground vector and the air vector -- you'll find your aircraft heading.

The preflight wind problem is one of many types of wind problems you'll solve with the DR computer. It is the one most commonly used by pilots and the one we will discuss. Throughout the discussion of the wind triangle, the wind vector will have both direction and speed. In future discussions it may be referred to as WV. This term is commonly used for wind speed coupled with wind direction. Before explaining the mechanics of the preflight wind triangle on the computer, you need to determine what kind of direction we're going to use. You must be consistent and use either magnetic or true direction throughout the problem.

TC + VAR = MC

MC + DC = MH

TC + VAR + DC = MH

Since DC in the formula is the difference between MC and MH we use magnetic direction. This means that MC is always read under the true index, and it also means the wind information received from the weather forecaster must be converted to magnetic direction. MH is always the result of applying DC to MC. The resultant wind triangle is composed of the following: Magnetic WV, MC and TAS, MH and groundspeed (GS). Of these components, magnetic WV, MC and TAS are known quantities. Use the computer to determine MH and GS.

Example 1: With the following information given, solve for MH and GS:

MAG WV - 300 degrees/40 knots

MC - 055 degrees

TAS - 435 knots

Solution: Determine which side of the slide to use. Since the TAS is 435 knots, use the high-speed side. Now, apply the wind to the computer by rotating the compass rose to place the magnetic direction of the wind under the true index. Next, place the grommet under any convenient speed circle, such as the 300- unit circle, and count up the number of increments equal to the speed of the wind. (This is the wind up method used by pilots.) Be sure to interpolate properly. At this point, make a small dot or tee (T) on the face of the computer.

Now, rotate the compass rose to place the MC, 055 degrees, under the true index, and move the computer slide until the dot or tee is over the speed line representing the TAS of 435 knots. Read the answer for GS under the grommet. GS = 450 knots. Determine the DC under the wind dot (five degrees), and apply it to the MC for MH of 050 degrees. The wind dot is five degrees to the left of the centerline, MH is found on the compass rose five degrees to the left of the true index along the drift correction scale, or a minus five degrees. If the wind dot is to the right of the centerline, MH is the same number of degrees on the compass rose to the right of the true index along the drift correction scale, or a plus number of degrees.

Example 2: Solve the following preflight problem:

Mag WV = 2450, MC 290 degrees, TAS = 220 knots

Solve for: MH and GS

Solution: Since the TAS is relatively low, use the low speed side of the slide. Set the magnetic wind direction under the true index. Place the grommet on a speed circle, count up to 50 knots for the wind velocity and make a pencil mark. Now rotate the compass rose until the MC of 290 degrees is under the true index. Set the pencil mark on the 220 (TAS) speed line and read the GS (185) under the grommet. The DC is under the pencil mark (-10 degrees) and should be applied to the MC to get a MH of 280 degrees.

Example 3:

TAS = 210 knots, TC=250 degrees, WV=0965, VAR=10 degrees W

Solve for: MH and GS

Answer: The TAS would fit on the low side, but you discovered you had to switch to the high-speed side because of the wind. Slight differences in computers can easily result in a two degree difference in DC in the above problem, hence the $\pm$ 2 degree tolerance. Normally, your answers on the high-speed side should be within $\pm$ 1 degree and $\pm$ 3 knots. Your answers should be MH = 255 degrees, GS = 268 knots.

8.8.3 Review

These next few paragraphs will review what we've learned in this unit. The variation angle is the difference between a true direction and a magnetic direction. The drift correction angle is the difference between a course and a heading.

On the wind face of the computer, your pencil mark indicates the direction and speed of the wind. The wind direction you obtained from the forecaster is based on true north. Therefore, be sure to add or subtract variation before you solve wind problems.

- Draw the Mag WV on the wind face side.
- Rotate the movable scale to place the MC under the index.
- Always place the penciled “T” on the speed line equal to TAS (T for true).
- Under the grommet you always find GS.
- The penciled mark appears on or near a heading line that indicates the degrees of DC. If the penciled mark is on the left, the DC is a minus DC; with a plus DC you add the DC angle to MC to determine MH.

8.8.4 Resolving a wind into its headwind component

In some preflight planning, the pilot must use a headwind component of a prevailing wind condition to determine the cruise power and fuel requirements. In aircraft with critical wind limitations for landings, the aircrew checklist usually includes a chart to break down the wind into its components. Unfortunately, these charts are limited to normal landing wind velocities, which are a fraction of the wind you encounter at altitude. To solve cruise problems, the wind face of the computer is the most expeditious means-both for preflight and in-flight problems.

You're planning to fly a long flight on a MC of 310 degrees with a prevailing wind of 280/80, and with a ten-degree easterly variation. To determine your best cruise TAS and fuel flow, you need to resolve the wind into its components.

There's a rectangular grid system with two scales at the bottom of the high-speed side of the slide. The left-side scale is marked off in increments of ten units per block and is used for large vector breakdowns, primarily above 60 knots. The right-side scale is marked off in three units per block and used for below 60 knots vectors. Choose your scale based on wind velocity. In this problem the high-speed scale is used, so slide it under the wind face compass rose.

The wind face true index is used as in a groundspeed problem, so rotate the compass rose until the magnetic wind is under the index (280 degrees-10 degrees = 270 degrees). Next, place the grommet over the wind velocity and draw a line from the “0” baseline to the grommet, representing the wind and its velocity. Now rotate the compass to your desired magnetic course (310 degrees) and slide the tail of the wind vector pencil line to the baseline and read the headwind component (65) under the grommet as shown. This is your headwind component for this wind and would be used in your preflight planning with the performance data charts to obtain the maximum range true airspeed.

Example 1:

True WV - 060/75

VAR - 10 degrees west

MC - 030 degrees

Answer: 060 degrees+10 degrees (west variation) = 070 degrees magnetic wind. Set 070 degrees under the true index and place the grommet over 75 on the center scale. Rotate the compass rose until the MC of the 030 degrees is under the true index then place the pencil mark on the baseline as shown on the illustration. The headwind component of the wind (55 knots) is under the grommet.

8.8.5 Proceeding directly to a DME fix

There are times when you'll be required to travel directly to a radial/DME. Your DR computer provides a quick and accurate method of computing a course and distance from one DME fix to another. You can use the DR computer for this both before and during flight.

Example problem: You're at point A, 100 NM out on the 090 degrees radial. You've just been cleared to go directly to point B, which is 80 NM out on the 180 degrees radial. What's the no-wind heading you'll fly to get to point B?

For the solution, follow these steps:

- Place the square grid portion of the computer slide under the wind face.
- The grommet always represents the station.
- Place the radial of your present position (090) under the true index.
- Place a dot, with a circle around it, 100 NM up from the grommet. (Be sure to use the graduated scale on the grid for distance.) This represents your position relative to the station.
- Place the radial of the fix to which you're going (180 degrees) under the true index.
- Place a dot 80 NM up from the grommet to represent point B.
- Rotate the compass rose to align the dots vertically making sure the dot with the circle (your position) is toward the bottom.
- The heading beneath the true index is your no wind heading to your new fix (231 degrees).
- Draw a line connecting the two dots. This represents your course and gives you a picture of your course relative to the station.
- To check your progress, place the radial you're crossing under the true index and compare the actual distance from the station with the desired distance on the computer.
- If you're off course you can make a correction. What should your distance from the station be when passing the 140 degrees radial?

Answer: 62 NM.

Example problem: Compute flight plan information for the following:

KNOWN		COMPUTE:	
Distance	200 nm	True Air Speed (TAS)	(2)
Course (TC)	270	Drift Correction (DC)	(3,4,5,6)
Variation	15 East	True Heading (TH)	(7)
Altitude	5,500 ft.	Magnetic Heading (MH)	(8)
Temperature	56F	Ground Speed (GS)	(9)
Calibrated Air Speed(CAS)	140mph (1)	Estimated Time Enroute (ETE)	(10)
Wind/Velocity	330 at 25 knots(330/25)	Estimated Fuel Use	(11)
Fuel Consumption	11 gal/hr		

Solution:

- (1) Convert all information into common units—either statute or nautical

  Place statute information (140 mph) opposite STAT arrow.

  Read nautical information opposite NAUT arrow - 122 knots

- (2) Compute TAS - Convert temperature to C if needed - 56° F = 13° C.

  56-32 = 24

  24/9 = 2.66

  2.66X5 = 13°C

  (Remember accuracy is only 2 digits)

  Set TEMP (56° F or 13° C) on rotating face opposite ALT (5.5) in the window

  Find CAS (122 knots) on MINUTES scale

  Read TAS on MILES scale..........133 knots

- (3) PUT W/V ON COMPUTER

  Position wind DIRECTION (330) on compass rose opposite TRUE INDEX

  Draw VELOCITY vector over centerline FROM grommet TOWARD True Index

  (Note the vector length, 25 units = wind velocity of 25 knots)

- (4) TURN COMPASS ROSE UNTIL TC IS UNDER TRUE INDEX Position 270 under TRUE INDEX

- (5) MOVE SLIDE UNTIL TAS IS UNDER TAIL OF WIND VECTOR 135 knots under TAIL of wind vector

- (6) READ DRIFT CORRECTION UNDER TAIL OF WIND VECTOR.- 9 right

- (7) COMPUTE TH (= TC +R or -L DC) - 270 + 90 = 279
- (8) COMPUTE MH (= TH +W or -E Var) 279 - 150 = 264
- (9) READ GS UNDER GROMMET - 120 knots
- (10) COMPUTE ETE FROM GS AND DIST

  Set INDEX on compass rose opposite GS (120)

  Read ETE on HOURS scale opposite DIST on MILES scale - 1:40
- (11) COMPUTE ESTIMATED FUEL USE

  Set INDEX on compass rose opposite FUEL CONSUMPTION (11 gal/hr)

  Read FUEL USE on MILES scale opposite ETE on HOURS scale - 18.2 gals
- (12) COMPUTE FLIGHT TIME AVAILABLE

  Set INDEX on compass rose opposite FUEL CONSUMPTION (11 gal/hr)

  Read FLIGHT TIME on HOURS scale opposite FUEL ON BOARD on MILES scale - 4:33

9. Search Planning and Coverage

This chapter will cover factors that are unique to search and rescue or disaster assessment mission planning. Planning considerations and techniques used in both visual and electronic search missions are included. Most of the planning is done by the incident commander and his staff; however, all crewmembers are expected to understand the planning concepts. Thorough comprehension allows more precise mission performance and increases flexibility, allowing you to effectively deal with changing circumstances.

The discussion that follows, and all future training and actual missions, relies heavily on understanding the "language" of search and rescue. A number of terms and planning factors must be understood when planning and executing search and rescue missions. Here are some important definitions:

Maximum Area of Possibility - This normally circular area is centered at the missing airplane's or search objective's last known position, corrected for the effect of wind. The circle's radius represents the maximum distance a missing aircraft might have flown based on estimated fuel endurance time and corrected for the effects of the wind over that same amount of time. The radius may also represent the maximum distance survivors might have traveled on foot, corrected for environmental or topographical conditions, such as snow, wind, mountains, and rivers.

Probability Area - This is a smaller area within the maximum possibility area, where, in the judgment of the incident commander or planners, there is an increased likelihood of locating the objective aircraft or survivor. Distress signals, sightings, radar track data, and the flight plan are typical factors that help define the probability area's boundaries.

Search Altitude - This is the altitude that the search aircraft flies above the ground.

Track Spacing - The distance between adjacent visual or electronic search flight legs.

Probability of Detection - The likelihood, expressed in a percent, that a search airplane might locate the objective. Probability of detection (POD) can be affected by weather, terrain, vegetation, skill of the search crew, and numerous other factors. When planning search missions, it is obviously more economical and most beneficial to survivors if you select a search altitude and track spacing that increases POD to the maximum, consistent with the flight conditions, team member experience levels, and safety.

9.1 Search Priorities

When faced with a lack of vital information concerning the missing aircraft, mission planners can either give the entire probability area search priority or select a portion of the probability area for a concentrated search. Some of the factors used in estimating the location of the missing aircraft within a portion of the probability area are:

- Areas of thunderstorm activity, severe turbulence, icing and frontal conditions.
- Areas where low clouds or poor visibility may have been encountered.
- Deviations in wind velocities from those forecast by the weather bureau.
- Areas of high ground.
- Any part of the aircraft's track that is not covered by radar.

9.1.1 Search Area Determination

The first task in planning a search and rescue mission is to establish the most probable position of the crash site or survivors. If witnesses or other sources provide reliable information concerning an accident, the location may be established without difficulty. If there is little or no information, the planners face a more difficult task. Regardless of the information available, search planners always prepare a chart to assist in focusing the search and locating the crash site or survivors as quickly as possible.

When defining search area limits, planners first sketch the maximum possibility area. They can focus the initial search in the most likely area and can use the charted area to help screen sightings and other reports. Again, the area is roughly circular, centered on the last known position of the missing aircraft. The radius approximates the distance the objective aircraft might have traveled, given the amount of fuel believed aboard at its last known position, and the wind

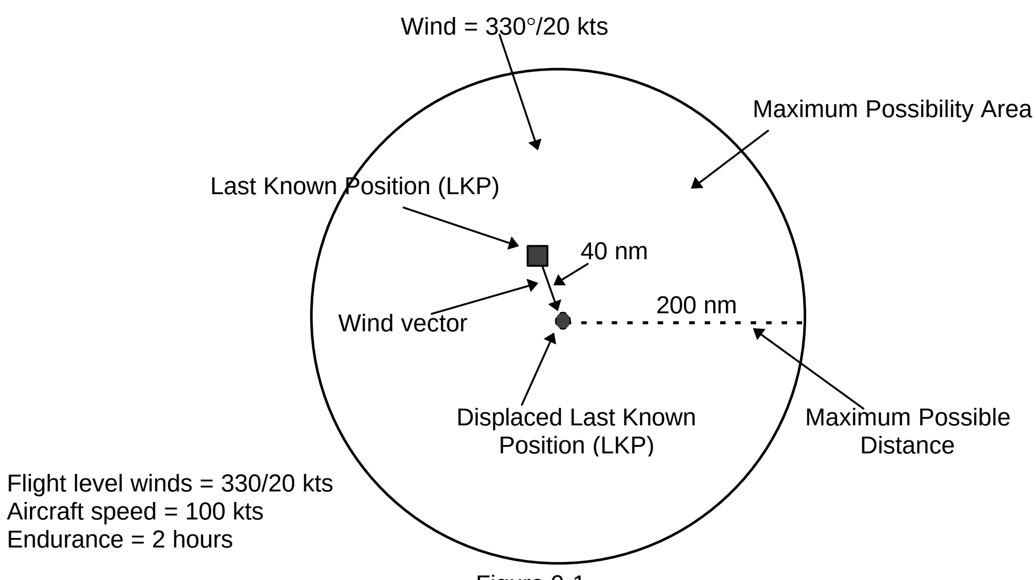


Figure 9-1

direction and speed. The area is circular because it's always possible the missing pilot may have changed directions following his last known position and flown until his fuel was exhausted.

To chart the maximum area of possibility, the planner requires the missing aircraft's last known position, wind direction and velocity, and an estimate of the missing aircraft's fuel endurance and airspeed. Figure 9-1 illustrates the use of these factors to chart the maximum area of possibility. The planner plots the missing aircraft's last known position on a sectional or other chart, then displaces the position for 2 hours of wind effect, or 40 NM, from 330°. From the displaced last known position, he draws a circle with a radius equal to the maximum distance flown by the aircraft. In this case, the planner estimated this range by multiplying aircraft speed, in this case 100 kts, by the estimated endurance of 2 hours.

9.1.2 Probability areas

Plotting the probability area (the area in the possibility circle where the searchers are most likely to find the aircraft) is the second major factor in search planning. The probability area is determined by the accuracy of the LKP in the possibility circle. Primary factors which contribute to the accuracy of the LKP are:

- The aircraft disappearance point on radar.
- The bearing or fix provided by other ground stations.
- Dead reckoning position based on the time of LKP.
- Reports of sightings-either ground or air.
- Emergency locator transmitter (ELT) reports.

There are instances where the above information is not available to assist the search planner. To establish a probable position in these instances, the search planner must rely on less specific secondary sources of information including:

- Flight plan.
- Weather information along the intended route or track.
- Proximity of airfields along route.
- Aircraft performance.
- Pilot's previous flying record.
- Radar coverage along the intended track.
- Nature of terrain along the intended track.
- Position and ground reports.

Based on experience and simulation provided by these factors, the search planner is able to define an area of highest priority to initiate the search. The first search area may be called probability area one. This area begins around the last known position, extends along the intended route and ends around the intended destination. If a search of probability area one produces negative results, the search may be expanded to cover probability area two, an extension of area one.

Organization is an important element in search planning. The time it takes to locate downed aircraft or survivors could depend on the definition and charting of the search area. As an observer, you should become familiar with each designated search area before the mission is launched. You should use current charts and maps which will enable you to provide additional navigational

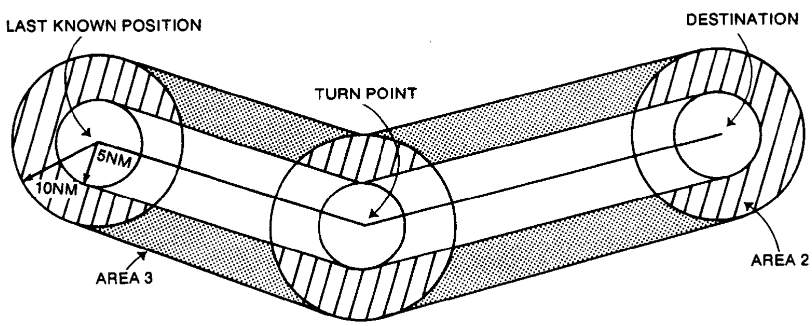


Figure 9-2

assistance in accurately positioning the search aircraft over the properly designated area.

Outlining the maximum area of possibility establishes an *initial* likely area where the missing aircraft might be located. In the earlier example, the maximum possibility area included over 120,000 square miles. The extensive size of the maximum possibility area makes systematic search neither efficient nor practical. It is essential that the planner further focus her search assets and attempt to further define the possible location area. To do this, the search planner charts a *probability area* within the possibility circle.

The probability area is determined by considering other factors that will help to reduce the area of intended search. These additional factors may include:

- Bearing or fix provided by other, non-radar, ground stations.
- Point where the aircraft disappeared from air traffic control radar.
- Dead reckoning position based on time of last known position.
- Reported sightings from either ground or air.
- SARSAT or emergency locator transmitter reports.
- Missing aircraft's flight plan.
- Weather information along the missing aircraft's intended route.
- Proximity of airfields along that route.
- Aircraft performance.
- Missing pilot's previous flying experience and habits.
- Radar coverage along the intended track.
- Nature of the terrain along the intended route.
- Position and ground reports.

In instances when little information is available to assist the planner, he or she reconstructs the incident flight with whatever information may be available. With no information, the search plan is based on an assumption that the missing aircraft is probably located along or near its intended course. The search is initially confined to an area five miles on either side of the intended course, beginning at the last known position and continuing to the intended destination. This first search area is called *probability area one.* The unshaded area in Figure 9-2 represents probability area one.

If search of probability area one produces no results, the search expands to include the area within a ten-mile radius of the last known position, destination, and intermediate points. This area is known as *probability area two* and is depicted by the hatched areas in Figure 9-2.

If the search still produces no results, a third search area is created. *Probability area three* includes areas ten miles either side of the missing aircraft's intended course, excluding those areas already searched in areas 1 and 2. Shaded areas in Figure 9-2 illustrate probability area three. If there is still no result, the incident commander may chart a new probability area within the possibility circle.

When other information *is* available that indicates any of the following factors may have been involved, the incident commander may also consider these factors when assigning priority to initial search areas:

- Areas of thunderstorm activity, severe turbulence, icing, frontal conditions, or any other weather condition that may have influenced a pilot to consider alternate routes to the destination.
- Areas where low clouds or poor visibility might have been encountered.
- Areas of high terrain or mountain passes.
- Any part of the aircraft's course is not covered by radar.
- Reports of ground sightings or of sound from low-flying aircraft.
- Point of last reported radio contact or MAYDAY broadcast.
- Deviations in wind velocities from those forecast.
- Survival factors.

In many military incidents, crewmembers of aircraft may eject or "bail out" of an aircraft prior to its collision with the ground. This is rare in civilian accidents, but if appropriate in either case, planners may also consider parachute drift factors when determining search areas.

9.1.3 Search Altitudes and Airspeeds

Once probability areas are identified, mission planners must make a number of choices as to the size and type of search patterns to be flown, search altitudes, and airspeeds. To make effective choices, the planner first considers factors beyond his or her control, including the size of the search objective, visibility, weather, and sea or terrain conditions.

The size of the search objective, weather, visibility, and ground cover in the search area must be considered when determining the altitude for a visual search. Over non-mountainous terrain, a search altitude between 1000 and 1500 feet above the terrain is normally used for a visual search. The search visibility and the terrain conditions may affect this selection. As altitude decreases below 500 feet, search effectiveness may actually decrease, due to the "rush effect" of objects on the ground passing through the scanner's field of view more rapidly.

Over mountainous terrain, the search altitude may be higher if the planner suspects wind and turbulence near the surface. During darkness, an altitude 3,000 feet above the terrain is considered adequate. Also, rugged terrain can easily block emergency radio transmissions, so electronic searches over such terrain are normally conducted at considerably higher altitudes than would be used during visual searches.

Depending upon the number of search aircraft available to the incident commander, he may also consider the desired probability of detection when selecting an altitude for the search pattern. Although a probability of detection chart is normally used to estimate POD *after* a search, its use here allows incident commanders to predetermine a mission's chance of success. Here's an example of using <u>desired</u> POD to help select a search altitude.

A red and white Cessna 172 has been reported missing and presumed down in eastern Arkansas, in open flat terrain. At the time of the search, flight visibility is forecast to be greater than ten miles. The incident commander determines, based on available aircraft and crews, that the single probability of detection for this first search must be at least 50%.

The POD chart excerpt in Figure 9-3 shows data for open, flat terrain. Other charts are available for hilly terrain or with moderate ground cover, and very hilly, or heavily covered terrain. To the right in the columns beneath "Search Visibility" you see what are, in this case, the desired probabilities of detection. Using one-mile track spacing, you can see that all three altitudes give at least 50% POD, but a search at 1000 feet above the terrain gives 60%, or 10% *more* POD than does a search at 500 feet. Over open terrain, where flight and search visibilities are not limiting factors, the chart demonstrates that a higher altitude is more likely to yield positive results on a single search. Notice that the highest POD in Figure 9-3, 85% is obtained when flying at 1,000 feet above the ground using a track spacing of 0.5 NM.

If weather or visibility are not limiting factor, why then don't you just always elect to fly *that* track spacing at 1,000 feet, and always try to obtain that highest of probabilities of detection? You should recall, from the earlier maximum probability area, that you start with a very large area, then try to focus your efforts on smaller probability areas within that larger area. If the IC/MC has received a number of leads that have reduced the probable area to a small size, he might task you to fly exactly that track spacing and altitude. If the area is not so small, and you try to fly 0.5 NM track spacing instead of 1.0 spacing, you will obviously take *twice* as long to cover the whole area.

OPEN, FLAT TERRAIN				
SEARCH ALTITUDE (AGL)	SEARCH VISIBILITY			
Track Spacing	1 mi	2 mi	3 mi	4 mi
500 Feet				
0.5 NM	35%	60%	75%	75%
1.0	20	35	50	**50**
1.5	15	25	35	40
2.0	10	20	30	30
700 Feet				
0.5 NM	40%	60%	75%	80%
1.0	20	35	50	55
1.5	15	25	40	40
2.0	10	20	30	35
1,000 Feet				
0.5 NM	40%	65%	80%	85%
1.0	25	40	55	**60**
1.5	15	30	40	45
2.0	15	20	30	35

Figure 9-3

The IC/MC also has another option -- he may use to increase the POD. Given adequate resources of aircraft and crews, he can significantly increase the POD by directing multiple searches of the same area, and increasing the amount of time that search forces cover the probability area. This can be demonstrated by using a cumulative POD chart, shown in Figure 9-4, and the earlier example of the missing red and white Cessna. The single-search POD for this hypothetical search was 60%. That mission was flown at 1,000 feet and 1.0 NM track spacing. If you, or another aircraft and crew, fly the same pattern a second time, the POD increases significantly. If the same search is flown again, with the exact same parameters for altitude and track spacing, the overall probability of detection, where the initial 60% intersects the subsequent same single POD, also 60%, is now 80% cumulative. A third search of the same area, again using the same parameters, brings the cumulative POD up to 90%. Since the cumulative POD increases with time in the search area, the incident commander has another option he can select to maximize search coverage.

9.1.4 Executing Search Patterns

The IC/MC and her staff take into consideration many variables including weather, visibility, aircraft speed, aircraft and crew resource availability, crew experience, and the urgency of the situation when developing the search plan. This section covered a number of factors that can affect the choice for search altitudes and track spacing. Similarly, mission planners consider many variables when selecting the search pattern or patterns to be used. Individual search patterns are covered in chapters that follow. All questions about how the search is to be conducted must be resolved at the mission briefing. When airborne, crews must focus on executing the briefed plan instead of second-guessing the planners and improvising.

9.1.5 Search Coverage Probability of Detection

Before a search mission gets airborne, each aircrew has a good idea of how much effort will be required to locate the search objective if it is in the assigned search area. This effort, expressed as a percentage, is the probability of detection, or POD. As a scanner/observer, you may be required to establish a POD for your aircrew's next sortie.

The following terms are associated with determining the probability of detection:

Meteorological visibility - the maximum range at which large objects, such as a mountain, can be seen.

Search visibility - the distance at which an object the size of an automobile on the ground can be seen and recognized from an aircraft in flight. Search visibility is always less than meteorological visibility.

Scanning range - the lateral distance from a scanner's search aircraft to an imaginary line on the ground parallel to the search aircraft's ground track. Within the area formed by the ground track and scanning range, the scanner is expected to have a good chance at spotting the search objective.

Ground track - an imaginary line on the ground which is made by an aircraft's flight path over the ground.

Search track - an imaginary swath across the surface, or ground. Its dimensions are formed by the scanning range and the length of the aircraft's ground track.

Track spacing - the distance between adjacent ground tracks. The idea here is for each search track to either touch or slightly overlap the previous one. It is the pilot's task to navigate so that the aircraft's ground track develops proper track spacing.

Possibility area – the area drawn on a map with its focus at the last known position (LKP) of the missing aircraft. Many factors are considered before establishing a possibility area, but it is the largest geographic area in which the aircraft might be found.

Probability area - the geographic area within which a missing aircraft is most likely to be.

9.2 Probability of detection

A scanner/observer can easily determine a probability of detection (POD) by gathering the data affecting the search and by using a POD chart to calculate the detection probability.

The type of terrain, ground foliage, altitude of the search aircraft, track spacing, and search visibility are vital factors in determining a POD. Once each of these factors is given a description or numerical value, the POD can be determined by comparing the search data with the POD chart data. The following discussion is based on this example search situation:

A Cessna 182, white with red striping along the fuselage and tail, was reported missing in the northwest area of Georgia. The last known position (LKP) of the airplane was 40 miles north of the city of Rome. Geological survey maps indicate that the probability area is very hilly and has dense or heavy tree cover. Current visibility in the area is 3 miles. A search for the airplane and its three occupants is launched using 700 feet AGL for the search altitude and a track spacing of 1.5 miles.

9.2.1 Probability of Detection Table

By referring to a POD chart you will note that there is approximately a 10% chance of locating the missing aircraft during a single search. Locate the numbers in the column describing heavy tree cover and hilly terrain which coincide with the search data mentioned above.

In cases where there are multiple or repeated searches over the same probability area, you should use the cumulative POD chart. This chart is as easy to use as the single search POD chart.

Using the same data that we just mentioned concerning the missing Cessna 182, we can determine the probability of detecting the aircraft during a second search of the probability area. In the first search the POD was ten percent. For the second search (assuming that the data remains the same as was specified for the first search), the POD would be ten percent. However, because this is a repeat, the overall POD increases to 15 percent.

Probably the greatest advantage of using the cumulative POD chart is to indicate to searchers how many times they may have to search a single area to

CUMULATIVE POD CHART

Previous, or Cumulative POD									
5-10%	15								
11-20%	20	25							
21-30%	30	35	45						
31-40%	40	45	50	60					
41-50%	50	55	60	65	70				
51-60%	60	65	65	70	75	80			
61-70%	70	70	75	80	80	85	90		
71-80%	80	80	80	85	85	90	90	95	
80%+	85	85	90	90	90	95	95	95	95+
	5-10%	11-20%	21-30%	31-40%	41-50%	51-60%	61-70%	71-80%	80%+
	POD THIS SEARCH								

Figure 9-4

obtain the desired overall POD. For instance, you may want a POD of 80 percent in an area before continuing to another area. If one search of probability area proves futile with a POD of 35 percent and a second search is conducted in the area with a POD of 40 percent, the cumulative POD can be determined easily. The observer in the aircraft would only have to locate the box that intersects the 35 percent POD with the 40 percent POD.

A look at the cumulative POD shows that these two searches would yield a cumulative POD of 60 percent. Therefore, you should search the area again.

Remember, the cumulative POD chart should be used when multiple searches are conducted over the same search area.

This general explanation of the cumulative POD chart has provided some basic information about its use. As a mission observer, you should not primarily concern yourself with extensive calculations involving the cumulative POD. Simply knowing the probability of detection for each mission and the factors contributing to that probability is enough involvement on the mission observer's part. The IC/MC is the primary individual who makes extensive use of the cumulative POD chart.

9.3 Sample Problems for Search Area Planning

Problem #1

Four aircraft have accumulated nine hours over a given search area at an average ground speed of 90 knots. If they used a track spacing (S) of two nm, what is the total area searched in thousands of square miles?

Problem #2

The area to be searched is before sunset is 6000 square nautical miles. With an average ground speed of 60 knots, six hours of good light left in the day, and a track spacing of 1.5 nm, how many aircraft will be required to complete the search?

Problem #3

The area to be searched is 5000 square nautical miles, and the IC/MC has selected two nm track spacing. With three aircraft capable of an average ground speed of 100 knots, how many hours will the search take?

1.1.1.1.1.9 Chapter
10

10. Electronic Search Patterns

While the mission observer's role seems to be concentrated in visual searches, his contributions in electronic searches are no less important. The observer's understanding of electronic search techniques, and his ability to assist the pilot can substantially increase both search effectiveness and the timeliness of recovering accident victims.

Electronic searches are most efficient when the equipment, the environment and the terrain are ideal. This includes flat, level terrain, few natural or man-made obstructions and properly functioning equipment. These ideals seldom exist. Therefore, the effectiveness of electronic searches depends heavily on the experience and expertise of the search crews employing them. Through practice, you will understand the difficulties caused by ELT signals reflected from obstructions, the adaptability of electronic search methods to overall conditions, and the monitoring of radio equipment to ensure proper operation.

The use of electronic equipment in locating missing aircraft or survivors is an alternative to visual searches. The primary equipment in these type searches is an emergency locator transmitter (ELT) and ELT reception device. Once it has been established that an ELT was on board the missing aircraft, a combined track route and ELT search can be launched. The success of this type of search depends on the life of the battery of the ELT, the survivability of the entire ELT unit and whether the unit was activated or not. There is always the possibility ELT equipment may be inoperable due to the effects of the crash. Since an ELT aboard an aircraft does not guarantee that it can be located with an electronic search, both an electronic search and a concentrated general search should be organized at the same time.

10.1 ELT and SARSAT

Electronic equipment and procedures are used in general searches to focus the search and rescue effort in a specific area, or as an alternative to visual searches when visibility is reduced by weather or other atmospheric conditions. Equipment used in these searches may include a battery-powered emergency locator transmitter (ELT) aboard the incident aircraft, search and rescue satellites, and an ELT receiver aboard the search aircraft.

The Federal Aviation Administration (FAA) requires most US-registered general aviation aircraft to have operable ELTs installed, which activate automatically when sensing acceleration forces during an accident. An active ELT transmits a continuous radio signal on a specific frequency until it’s either deactivated or its battery discharges.

In a cooperative effort among several nations, search and rescue-dedicated satellites (SARSATs) orbit the earth and alert to ELT transmissions. Upon receiving an ELT signal, the SARSAT derives the approximate lat/long coordinates of the ELT position, and the coordinates are passed through rescue channels to the incident commander. Aboard the search aircraft, a radio receives the ELT signal, and converts it into an audible tone and a signal that's processed by the direction finder. The direction finder (DF) provides the crew with relative direction, or bearing, to the transmitter.

Upon receiving SARSAT coordinates, or determining that an ELT was aboard a missing aircraft, the IC/MC may launch a combined ELT and visual route search. Search success may depend upon several factors. The fact that an ELT was aboard a missing aircraft does not necessarily guarantee that electronic search procedures will locate it because the unit may have been inoperative or the batteries totally discharged. Also, the crash forces may have been insufficient to activate the ELT or so severe that it was damaged. Incident commanders may attempt to maximize the search effort by conducting an electronic search and a general visual search simultaneously when weather and other circumstances permit.

10.2 Track crawl and parallel track

Before you can use any technique to locate an ELT, you must first be able to pick it up on your radio. The track line (route) pattern (Figure 10-1) or the parallel track (Figure 10-2) search patterns are the most effective at this stage. The aircraft conducting an electronic search will normally begin the search at or near the last known point (LKP), and fly the search pattern at altitudes from 5,000 to 10,000 feet above the terrain, if possible. At this altitude, the aircraft can usually intercept the ELT signal and may be able to see the crash site. At the maximum electronic search altitude, which is much higher than 10,000 feet, chances are slim that one can recognize or distinguish a light plane crash site. Maximum track spacing should be used initially to provide a rapid sweep of the probability area. Successive sweeps should have a track spacing one-half the size of the initial spacing. For example, if the track spacing is 60 nautical miles during the initial sweep of the area, then the track spacing for the second sweep of the area should be 30 nautical miles. A third sweep of the area, if needed, should have track spacing of 15 nautical miles. This method of gauging the track spacing applies to both track line (route) and the parallel track. These procedures may by repeated until the missing aircraft or survivors are located, or until it is presumed that the batteries of the ELT have been exhausted.

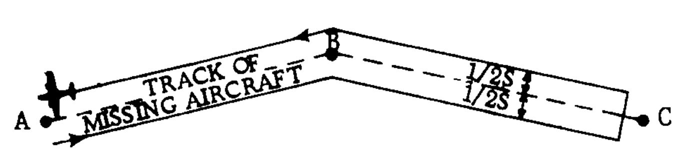


Figure 10-1

In mountainous terrain the initial search pattern should be arranged to cross ridgelines at right angles, if at all possible. The search coverage of the area should be at right angles to the first coverage tracks to compensate for blockage of the ELT signal due to the shape of the terrain.

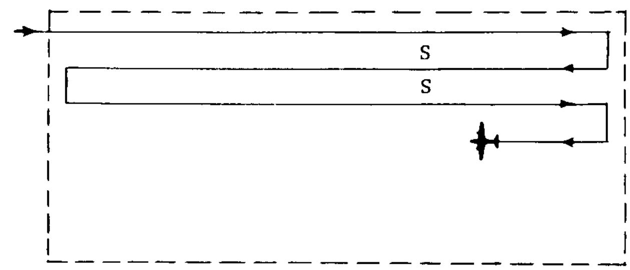


Figure 10-2

Once the searchers are in a position to receive the ELT signal, they may use one of several methods to locate the transmitter and the accident scene. Homing is the simplest and most common method, but it requires special equipment that is not installed in all search airplanes. The metered search also requires special equipment that may not always be available. The signal-null and aural search methods are used less frequently, but they may be used aboard any airplane equipped with a radio receiver. Each requires only the crew's ability to hear the ELT tone through the search aircraft's radio or intercom.

10.3 Homing

Homing is an electronic search method that uses a direction finder to track the ELT signal to its source. With the direction finder (DF) set to the ELT operating frequency (121.5 MHz; 243.0 MHz for military aircraft), the pilot will fly the aircraft to the transmitter by keeping the left/right needle centered. ELTs may transmit on either 121.5 MHz VHF, 243.0 MHz UHF, or both frequencies simultaneously. These emergency frequencies are *usually* the ones monitored during a search, but homing procedures can be used on any radio frequency to which *both* a transmitter and DF receiver can be tuned.

In order to for the DF part of the ELT receiver to function, the “Alarm” toggle switch must be in the ‘down’ position. Also, the observer must maintain the DF unit’s “signal strength” needle centered with the signal strength control knob.

In the following scenario, the search objective is an active ELT at a crash site. The first step is to tune the receiver to the ELT frequency and listen for the warbling tone of the ELT signal. Next you have to determine the direction to the ELT. When you fly directly toward a signal, the left/right needle remains centered. However, when you head directly *away* from the signal, the needle also centers. A simple, quick maneuver is used to determine if you are going toward or away from the signal.

Starting with the left/right needle centered, the pilot turns the aircraft in either direction, so that the needle moves away from center. If he turns left, and the needle deflects to the right, the ELT is in front. If the pilot turns back to the right to center the needle, then maintains the needle in the center, you will eventually fly to the ELT.

If, in the verification turn, the pilot turns left and the needle swings to the extreme left, then the ELT is behind you. Continue the left turn until the needle returns to the center. You are now heading toward the ELT, and as long as the pilot maintains the needle in the center, you will fly to the ELT.

Flying toward the ELT and maintaining the needle in the center of the indicator *is* the actual homing process. If the needle starts to drift left of center, steer slightly left to bring the needle back to the center. If it starts to drift right, turn slightly back to the right. Once you have completed the direction-verification turn, you will not need large steering corrections to keep the needle in the center.

When passing over the ELT or transmission source, the left/right needle will indicate a *strong* crossover pattern. The needle will make a distinct left-to-right or right-to-left movement and then return to the center. This crossover movement is *not* a mere fluctuation; the needle swings fully, from one side of the indicator to the other and then returns to the center.

During homing you may encounter situations where the needle *suddenly* drifts to one side then returns to center. If the heading has been steady, and the needle previously centered, such a fluctuation may have been caused by a signal from a second transmitter. Another aircraft nearby can also cause momentary needle fluctuations that you might not hear, but the needle in the DF will react to it. Signal reflections from objects or high terrain can also cause needle fluctuations at low altitudes in mountainous terrain or near metropolitan areas.

10.4 Wing shadow method (signal null)

The signal null or wing shadow method is based on the assumption that the metal skin of the search aircraft's wing and fuselage will block incoming ELT signals from the receiving antenna during steep-banked turns. The observer can make simple estimates of the magnetic bearing to the transmitter by checking the aircraft heading when the signal is blocked.

Once the search aircraft completes several signal-blocking turns in different sectors of the search area, the observer can establish the approximate location of the ELT by drawing magnetic bearings, or "null vectors," on the sectional chart. The ELT and accident scene will be at or near the intersection of the null vectors.

To use the null method, the search aircraft must be made of metal so that the ELT signal can be blocked. Aircraft having fabric or plywood covered wings are not suitable for the null search method, because the wings may not block the signal well enough for the method to work properly. You must also know the location of the receiving antenna (i.e., on the bottom or the top of the aircraft).

10.4.1 Procedures

First, verify the receiver is tuned to the proper ELT frequency and that you can hear the warbling tone. Mark your position on the sectional chart, preferably over a small but significant feature. Then the pilot will make a 360°, <u>steeply-banked</u> turn to allow you to determine the signal's direction. As the airplane turns, the ELT tone will break, or null, at the point when the aircraft wing and skin come between the transmitter and the antenna. For a brief instant you will not hear the tone. The absence of the audible tone is referred to as the *null*.

On aircraft with the antenna installed on the underside, the wing inside the turn ("down" wing) of the banking airplane, points toward the ELT when the tone nulls. On aircraft with the antenna installed on the top, the wing on the outside of the turn ("up" wing) points toward the ELT when the null is heard.

To estimate the magnetic bearing from the search airplane to the ELT, the observer makes simple calculations. In high-wing airplanes, if you're turning left,

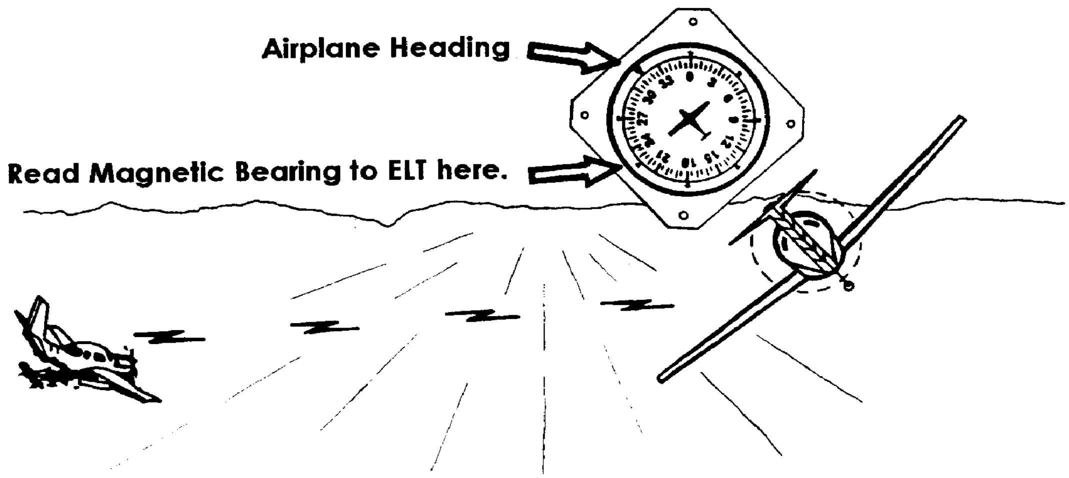


Figure 10-3

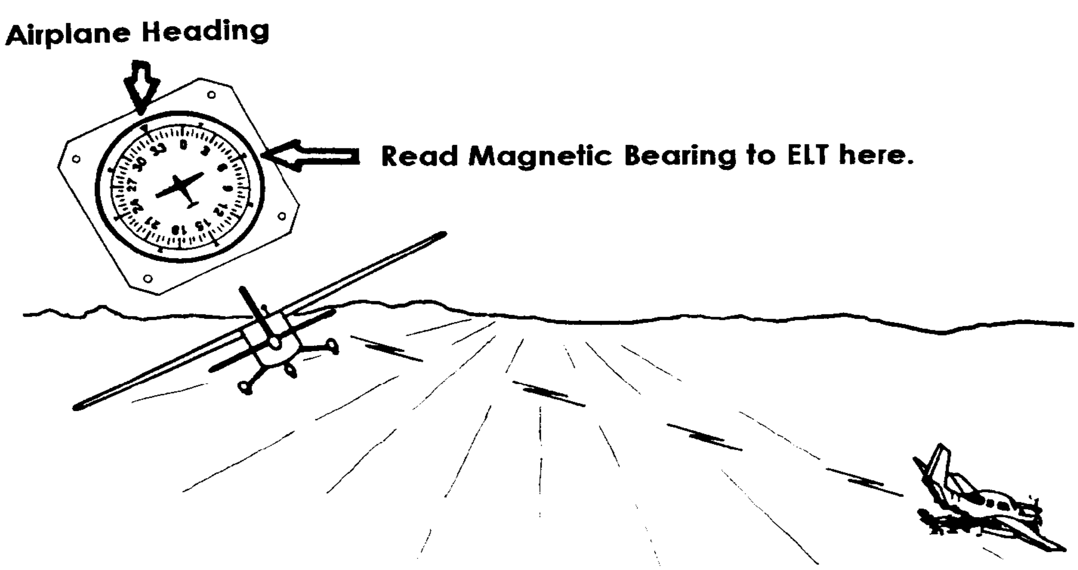


Figure 10-4

add 90° to the aircraft heading when you hear the tone null. If you're turning right, subtract 90° from the heading at the instant you hear the tone null. In low-wing airplanes, when you're turning left, subtract 90° from the aircraft heading, and when making right turns, add 90° to aircraft heading.

You may find it simpler to make these bearing estimates using the face of the heading indicator. Imagine an aircraft silhouette on the face of the search airplane's heading indicator. The silhouette's nose points up toward the twelve o'clock position, and the tail points toward the bottom or six o'clock position. The left wing points left to nine o'clock, and the right wing points to three o'clock. Some heading indicators actually have this silhouette painted on the instrument face, as shown in Figures 9-3 and 9-4. This imaginary plane always mimics whatever the search airplane is really doing.

Upon hearing the null, the observer should quickly look at the heading indicator. If the search aircraft is a low-wing aircraft, like the *Cherokee,* look for the number adjacent to the imaginary aircraft's low wing, as shown in Figure 10-3. If the search plane is a high-wing, like the Cessna 172, look for the number adjacent to the imaginary plane's high wing, as shown in Figure 10-4. That number is the magnetic bearing from the search aircraft's present position to the ELT transmitter.

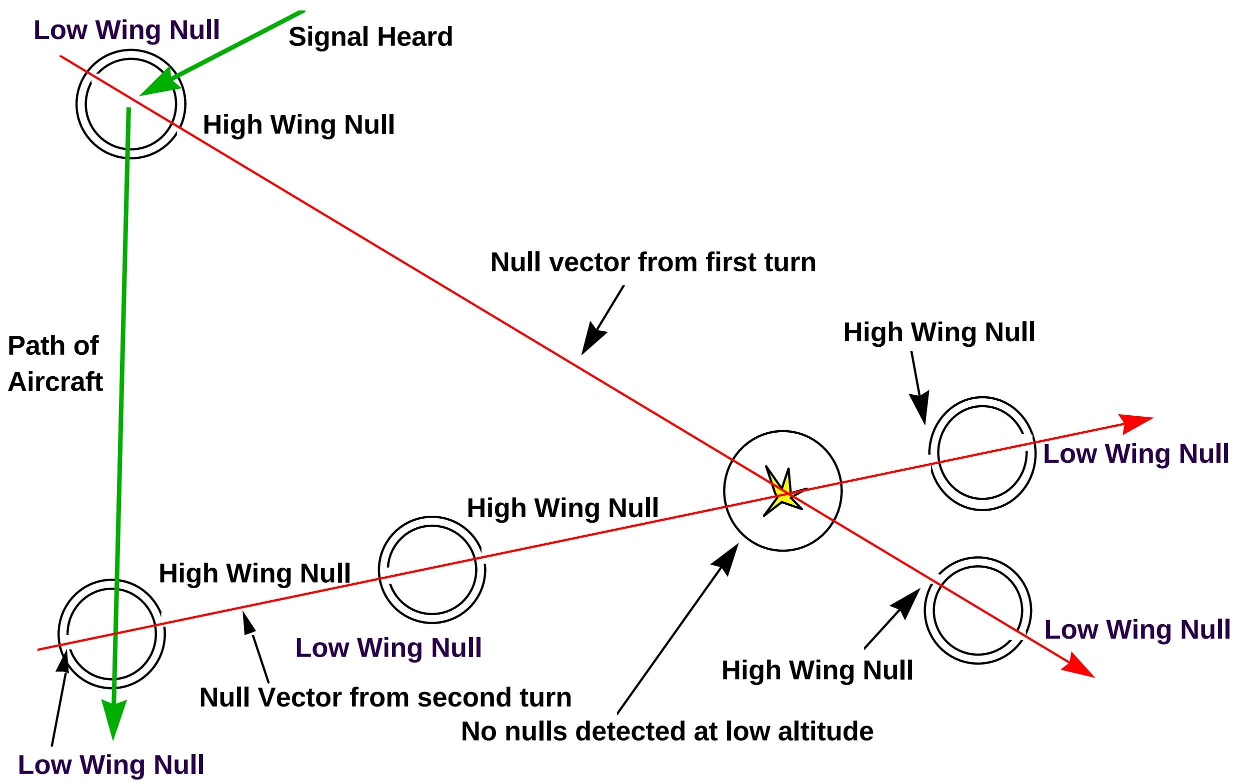


Figure 10-5

Regardless of the method used to determine the ELT's magnetic bearing, the next step is to convert that magnetic bearing to a true bearing by adding or subtracting the published magnetic variation for that area. Then draw a line on your chart from the search aircraft's known position in the direction of the calculated true bearing. You now have one null vector, or line of position, to the ELT. The ELT is somewhere along that line, but it isn't possible to tell exactly where. To narrow the focus, simply repeat the process starting from another known position over a different geographical point. Don't pick your next geographical point near to or along the initial null vector. The accuracy of this technique improves if you select geographic points well away from each other. If the points are well separated, the null vector lines will intersect at a larger angle, and the position will be more accurate. Figure 10-5 shows an entire null signal search. Notice that several fixes may be taken before deciding the limits for the subsequent visual search. Finally, fly to the area indicated by the null-vector intersection and attempt to pinpoint the ELT.

Upon reaching the area, the pilot can descend to a lower altitude and execute similar steep turns. If you are very close to the ELT, you can expect to hear no null, due to the higher signal strength near the transmitter and the inability of the wing to block the signal. When an ELT tone is continuous through a full 360° turn, the ELT transmission is very likely in the area beneath the search aircraft. You can then chart the probable location of the missing aircraft or transmitter to within a small area.

If descending to a lower altitude brings the aircraft within 1,000-2,000 feet above the terrain, you should discontinue null procedures. Instead, you should descend to an appropriate lower altitude and begin a visual search.

10.4.2 Special Considerations in Signal Null Searches

Four special considerations must be made prior to and during signal null searches. The most important is crew ability. Maintaining altitude throughout steep turns requires skill and extensive practice. Some aircraft may stall and then spin if over-controlled in poorly executed turns. This can result in a great loss of altitude, structural damage to the airplane during recovery, or collision with the ground. The pilot must be skilled in executing steep-banked turns.

Second is positive knowledge by the search crew of its actual position when the null is heard. By constantly monitoring the search aircraft's position in the turn, you can plot each null vector more precisely.

Third, the search crew must know what to do if the signal is lost during a search. If you lose the signal while trying to pinpoint the ELT's location, you can return to the position and altitude of the last contact with the tone. The observer's chart is a useful record of each position where successful procedures were performed.

Finally, as you approach the suspected ELT location, be more alert for other aircraft. Since a search is likely to include more than just your airplane, you should expect the ELT location to become a point of convergence for all aircraft involved in the search. Once you establish the general location of the downed aircraft, you *must* approach the area with caution. A midair collision can easily result if the entire crew's attention is focused on the accident scene while other aircraft approach the same area.

10.5 Aural (or hearing) search

The aural or hearing search technique is based on an assumption that an ELT's area of apparent equal signal strength is circular. Throughout this procedure the observer *must not* adjust the receiver volume. A constant volume helps assure that "signal heard" and "signal fade" positions will remain consistent.

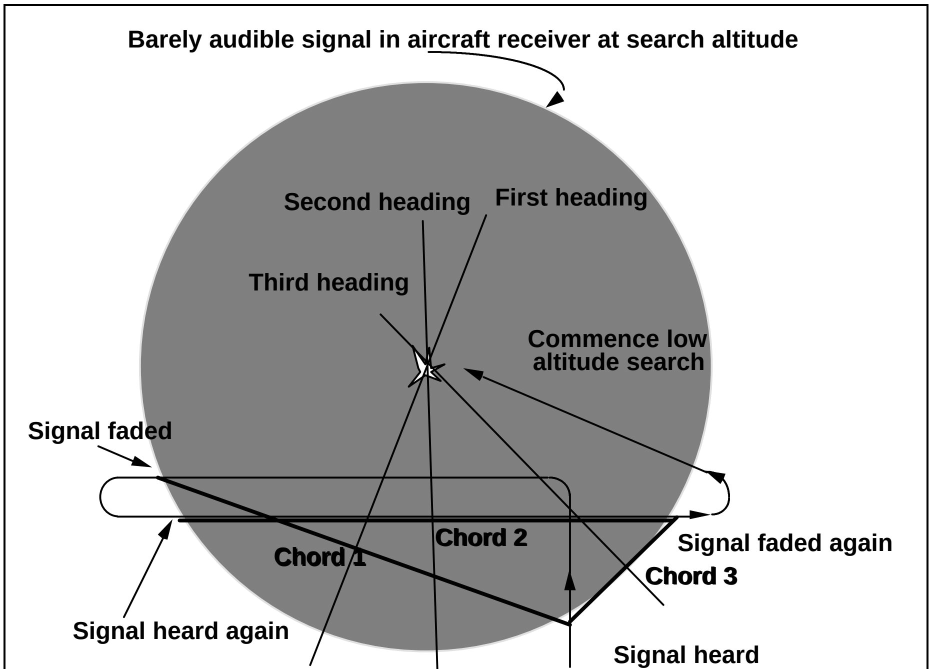


Figure 10-6

Also, once you begin the procedure, make all turns in the same direction as the first turn if terrain permits. The observer begins the aural search by plotting the search plane’s position when the ELT tone is first heard. The pilot continues flying in the same direction for a short distance, then turns 90° left or right and proceeds until the tone volume fades. The observer charts the aircraft position where the tone volume fades. The pilot then reverses aircraft direction, and the observer again marks on the map the positions where the signal is heard again and where it fades. If the radio volume has not been adjusted, the "signal fades" and "signal heard" positions should be approximately equidistant from the ELT. To determine the approximate location of the ELT, the observer draws lines to connect each set of “signal heard” and “signal fade” positions.

At the midpoint of each of these new lines, or chord lines, the observer constructs a bisector, a perpendicular line that points toward the center of the search area. The point where these bisectors intersect is the approximate location of the ELT. Figure 10-6 illustrates the connection of the signal heard and signal fade positions with the chord lines, the perpendicular bisectors' converging toward the center of the search area, and the intersection over the probable location of the ELT. Once the observer establishes the approximate location of the missing aircraft, the pilot flies to that location and the crew begins a low-altitude visual search.

The crew must remember that locating the ELT in this fashion is not precise. The determination is approximate because the area of equal signal strength on which this procedure is based is seldom, if ever, perfectly circular. The perpendicular bisectors rarely intersect directly over the objective. However, a low-altitude visual search of the general area can help compensate for lack of precise location.

This pattern is based on the assumption that the area of equal beacon signal strength is circular. When using this procedure, which does not require a special antenna, the search aircraft is flown in a "boxing in" pattern. The observer begins the aural search method by plotting the search aircraft's position as soon as the ELT signal is heard. The pilot continues on the same course for a short distance, then turns 90 degrees either to the left or right and proceeds until the signal fades.

Next the observer charts the positions where the signal fades. The pilot turns the aircraft 180 degrees and once again the observer marks on the map the positions where the signal is heard and where it fades. During this procedure the observer should not adjust the receiver volume. A standard volume ensures that the "signal heard" and "signal fade" positions will remain constant.

To establish the approximate position of the ELT unit, the observer draws chord lines between each set of "signal heard" and "signal fade" positions. Then the observer draws perpendicular bisectors on each chord. The bisectors are drawn from the mid-point of each chord toward the center of the search area. The point where the perpendicular bisectors meet, or intersect, is the approximate location of the ELT unit. After the observer establishes the approximate location where the missing aircraft may be found, the pilot flies to that location and begins a low-altitude visual search pattern.

The observer should remember that the calculations on pinpointing the location of the ELT unit are approximate, not exact. The calculations are called approximate because the area of equal signal strength on which this procedure is based is seldom, if ever, circular. Thus the perpendicular bisectors seldom intersect directly over the target. However, low-altitude visual searches over the general area, pinpointed with the aural search method, compensate for the lack of exact target location.

10.6 Metered search

To employ the metered search method, the observer uses a signal strength meter to monitor the ELT signal. Referring to Figure 10-7, the circled numbers represent the sequence of events and numbers plotted along the track are hypothetical signal meter readings, with higher numbers representing weaker signals and lower numbers representing stronger signals.

Once the aircraft enters the search area, the observer plots two positions of equal meter strength. For example, as the aircraft enters the search area, assume the signal strength measures 8.0. The observer records the signal strength and notes the search aircraft's position. As the search aircraft continues, the signal strength increases and then begins to diminish, or weaken. When the signal registers 8.0 again on the meter, the observer plots the midpoint between these two points, while the pilot makes a 180-degree turn and flies toward the midpoint. Upon reaching the midpoint, the pilot makes a 90-degree turn to the right or left. If the signal strength begins to fade, the search aircraft is heading in the wrong direction. The pilot corrects the direction by making a 180-degree turn. This change in heading now carries the search aircraft toward the ELT signal. As the aircraft is flying on a heading toward the ELT signal, the observer again plots

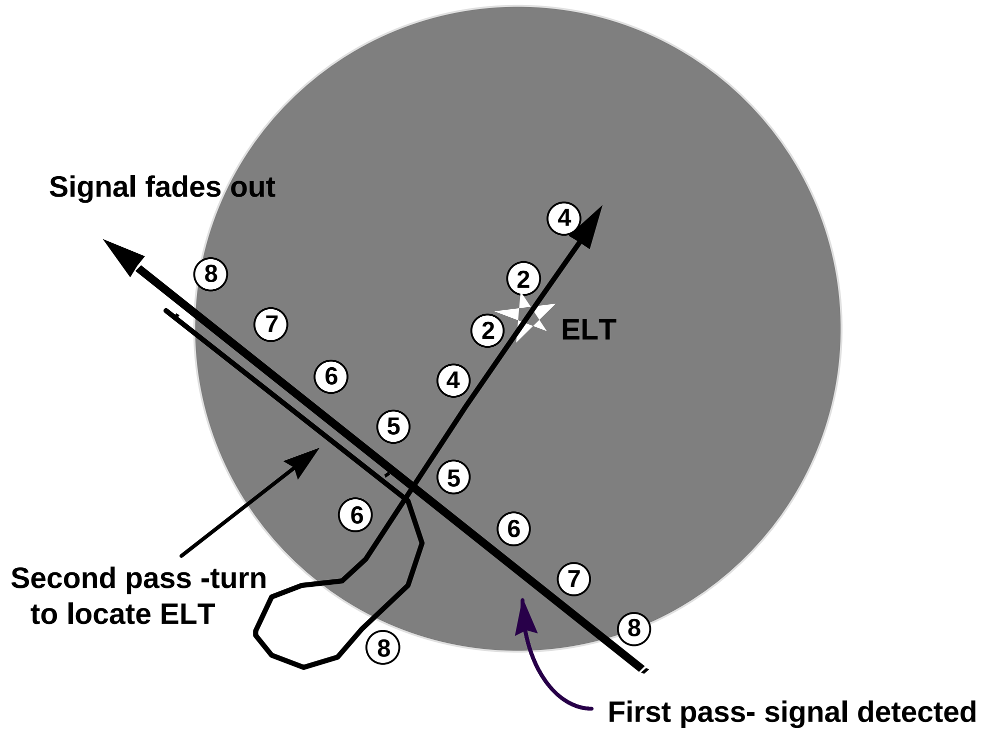


Figure 10-7

two points of equal meter reading. As the second point of equal strength is passed, the pilot makes a 180-degree turn and descends to the area that emitted the strongest signal. Upon reaching this area, the search crew begins a visual search at an appropriate altitude. The numbers plotted along the search track are signal meter readings with the higher numbers representing the weaker signals and the lower numbers indicating the stronger signals. When search crews properly use this method they can quickly locate the ELT unit and downed aircraft.

10.7 Night and IFR electronic search

Each of the preceding electronic search methods has certain limitations that effect its usefulness during darkness or in instrument conditions. In this discussion, “instrument conditions” means weather conditions that compel the pilot and crew to operate and navigate the aircraft by referencing onboard instruments and navigational radios. Never conduct searches requiring steep turns in instrument conditions!

Darkness and poor weather reduces your ability to precisely determine your position, and that impacts the effectiveness of all electronic search procedures. The accuracy of the null vectors, "signal heard" and "signal fade" points, and points of equal meter signal strength all depend on your ability to accurately fix your position over the ground. Even when you've successfully homed to an ELT, unless you can accurately determine your position, you've only succeeded in narrowing the general area for ground search efforts that follow. GPS (or LORAN) and VOR equipment help regain some of this lost capability.

Other considerations relate to safety and qualifications. The FAA requires that, for flight in instrument conditions, both pilot and airplane must have special certification. Instrument flight imposes a higher workload on the crew and demands a higher level of training, especially for the pilot. As discussed earlier, the ability to fly steep-banked turns and other maneuvers without losing altitude is demanding for even the most proficient pilot. Trying to conduct these maneuvers in darkness or while flying solely by referencing the flight instruments is not allowed. The pilot could easily get vertigo and lose control of the aircraft. If the search is conducted in instrument conditions, DF homing with the use of accurate navigational aids is the only method that may be allowed.

10.8 Signal Reflection and Interference

Radio signals reflect off terrain and manmade objects, and this can be a problem for search and rescue teams. In an electronic search, it is vitally important to know if the equipment is reacting to reflected signals and what you can do to overcome the problem. Although tracking a signal is the best means of locating an ELT, actually isolating the signal can occasionally become a problem. The following scenario illustrates one approach to a signal reflection problem.

After receiving a briefing, the pilot and observer check their aircraft and take off. Upon reaching the designated search area, the observer picks up an ELT signal. Using the DF, the search crew follows the signal for 10 minutes in a northerly direction. The observer later notes that keeping the left/right needle centered requires a 60° turn. This sudden turn causes the observer to conclude the signal is being reflected for two reasons. First, it is highly unlikely that the aircraft wreckage moved, causing a change in direction. Second, if sufficient crosswind was present to cause the change, it should have been noticeable earlier. Since the wreck didn't move, and there is no significant crosswind, the observer concluded that the apparent course problem was caused by reflected signals.

The observer can have the pilot climb to a higher altitude to eliminate or minimize the effects of reflected signals. Reflected signals are usually weaker than those coming directly from the transmitter, so climbing can help the stronger direct signals come through. Also, depending on the terrain, a higher altitude may result in more time available for the crew to detect the transmitter. Figure 10-8 shows how climbing to a higher altitude can help overcome the problem of signals blocked by terrain.

The specific pattern used during an electronic search over mountainous or hilly terrain can help compensate for blocked signals and reflections. You should alternate flying patterns parallel to valleys or ridges, and flying the patterns at perpendicular angles. The following example demonstrates this technique.

The crew receives the briefing and flies to its assigned area. The rectangular-shaped area is divided by a range of mountains extending north to south. The search crew elects to fly the initial pattern over the area east to west, then returns west to east. After making five uneventful passes over the mountains at 10,000 feet above the terrain, the observer hears the ELT on the sixth pass. On subsequent passes the observer hears the signal for three minutes during each pass and plots each area where the signal was audible. To further define the ELT position, the observer requests the pilot fly a course perpendicular to the previous

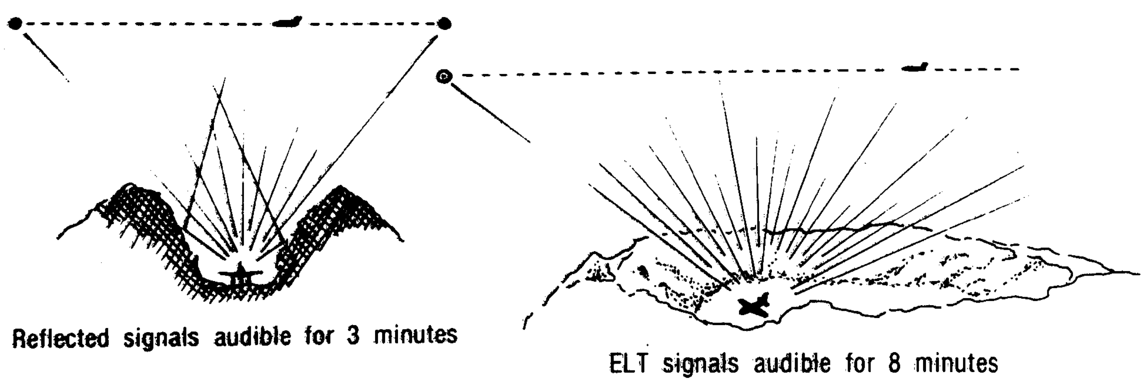


Figure 10-8

headings. This new course takes the aircraft parallel to the mountain range. On the third pass near the mountains, the observer hears the ELT again, this time for eight minutes. After another pass over the area to verify the eight-minute reception, the observer plots a small area on the map as a likely location of the ELT. The observer concludes that terrain is a major factor in causing the signal to be audible for short periods of time. The missing aircraft has possibly crashed in a ravine or narrow canyon that permits transmission of the ELT signals to a limited area above the crash site.

Descent to a lower altitude helps confirm the observer's speculation. The missing aircraft has crashed in a long, narrow ravine running parallel to the north-south mountain range. The mountain walls around the aircraft significantly limit transmission of the signals in an east-west direction, so the observer is only able to hear the signal for three minutes while searching in an east-to-west or west-to-east direction. When the aircraft track is parallel to the mountain range, the observer hears the signal for eight minutes. When the crew flies along the length of the ravine where the plane crashed, they are able to maintain signal contact for a longer time. Figure 10-8 also illustrates this effect.

When faced with strange circumstances like the two examples described above, try to visualize the situation and search for a logical explanation. Consider every factor that could cause the problem, including equipment reliability, terrain, other sources of interference like the electrical fields of high-tension power transmission lines, and the direction finding procedures themselves. If one method of electronic search doesn't yield the results you expect, try another method. Don’t become so involved with one method that you can't switch to a more suitable method if the situation demands.

Electronic searches are normally only as effective as the crews employing them. They work best when the equipment, environment, and terrain are ideal. Unfortunately, such ideal conditions seldom exist. Crews must practice search methods to better understand difficulties caused by various conditions. This will help you be prepared to deal with less than ideal conditions. Whenever you are faced with strange circumstances, you should seek the most logical explanation. In looking at the problem, always consider every factor that could possibly cause the situation. Consider the equipment reliability, the terrain and the DF procedures. If one method of electronic search doesn't yield the type of results you expect, try another method. Don't become so involved in one method that you can't adopt a more suitable method if the situation demands it.

1.1.1.1.1.10 Chapter

11

11. Visual Search Patterns

Almost all search and rescue missions are concluded by visual searches of the most probable areas once good information has been received from electronic searches, SARSATs, or other sources. This chapter will cover visual search patterns, some advantages and disadvantages of each, and some of the factors that help determine the type of search pattern you should use. The observer and mission pilot must carefully assess several important factors and their effects that go into the planning phase of a search operation.

11.1 Planning Search Patterns

Before missions are launched, the briefing officer provides pilots and crew members with information designating the routes to and from the search area, transit and area search altitudes, communications procedures, and the type(s) of search pattern to be used in the search area. Mission observers, who assist in navigation, must be familiar with each type of search pattern since each requires precise navigation and technique.

CAP aircrews use the GPS as its primary navigational and search pattern tool because of its versatility and accuracy. Dead reckoning is the least effective navigational method to aid aircrews in covering search areas adequately. If there are prominent landmarks in the area, aircrew members can use dead reckoning with some degree of effectiveness by taking frequent compass and drift readings. However, dead reckoning is not used since more accurate means of navigation are available.

Several types of visual search patterns are used in search and rescue. Many straight line “patterns” are simple while others are more complex. When flying each pattern, navigational accuracy directly affects search adequacy and the probability of detecting the objective.

The following discussions are directed primarily toward a single aircraft search, but the same general procedures apply when multiple aircraft are involved. The descriptions will cover track line, parallel, creeping line, square, and contour search patterns.

11.2 Route (track line) search

Search planners will normally use the route search pattern when an aircraft has disappeared without a trace. This search pattern is based on the assumption that the missing aircraft has crashed or made a forced landing on or near its intended track (route). It is also assumed that detection may be aided by survivor signals. Search planners often use the track line pattern for night searches in suitable weather. A search aircraft using the track line pattern flies a rapid route

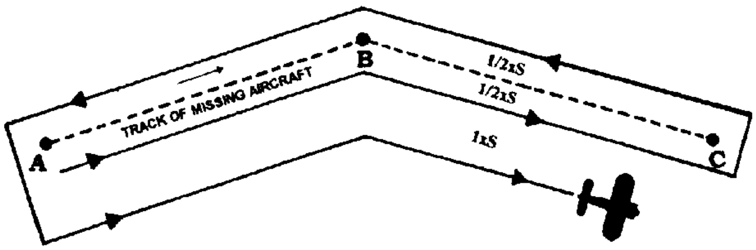


Figure 11-1

on either side of the missing aircraft's intended track. At the beginning point of a search, the aircraft begins with one-half search track spacing from the trackline.

Figure 11-1 illustrates the route (track line) search pattern. The search altitude for the track line pattern usually ranges from 1000 feet above ground level (AGL) to 2000 feet AGL for day searches, while night searches range from 2000 to 3000 feet AGL. Search altitudes are determined primarily by weather, light and visibility conditions. This pattern provides reasonably thorough coverage.

The search crew begins by flying parallel to the missing aircraft's intended course line, using the track spacing (labeled “S” in Figure 11-1) assigned during briefing. On the first pass, recommended spacing may be one-half that to be flown on successive passes. Search coverage is increased if you fly one-half “S” track spacing in the area where the search objective is most likely to be found.

11.3 Parallel track or parallel sweep

This procedure is used when one or more of the following conditions exist:

- the search area is large and fairly level.
- only the approximate location of the target is known.
- uniform coverage is desired.

Refer to Figure 11-2. The aircraft proceeds to a corner of the search area and flies at the assigned altitude, sweeping the area maintaining parallel tracks. The first track is at a distance equal to one-half the track spacing (½ x S) from the side of the area.

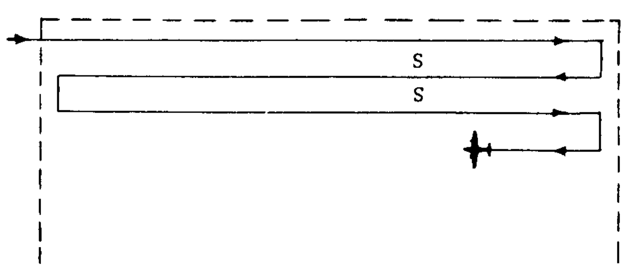


Figure 11-2

When more than one aircraft is available a variation of the parallel track search, the parallel sweep, can be used as shown in Figure 11-3. This sweep pattern is used when a search of a large area in a minimum amount of time is desired. However, a large number of aircraft are required to carry out this type of search. All aircraft report to the last reported position of the distressed unit before they go to their own "out" search tracks. Presuming that all search aircraft will return to the search base, the initial track spacing assigned is (2 x S) for that particular search. There should be a distance of one 'S' between out and in tracks. If sufficient aircraft are not available to effect this type of search, it may be possible to use aircraft regularly traveling this route to assist.

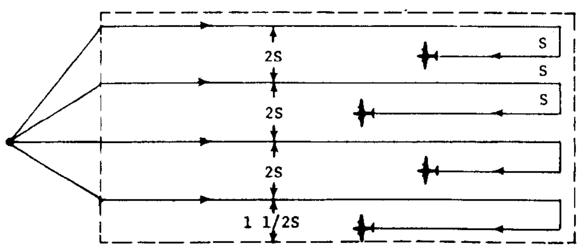


Figure 11-3

11.4 Creeping line search

The creeping line search pattern is similar to the parallel patterns. The parallel pattern search legs are aligned with the major, or longer, axis of the rectangular search areas, whereas the search legs of the creeping line pattern are aligned with the minor or shorter axis of rectangular search areas. Figure 11-4 shows the layout of this search pattern. Search planners use the creeping line pattern when:

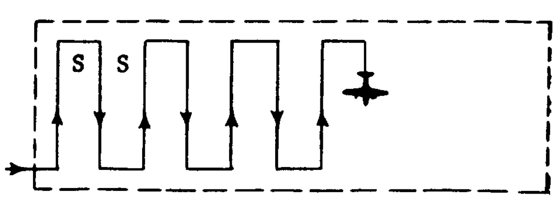


Figure 11-4

- The search area is narrow, long, and fairly level.
- The probable location of the target is thought to be on either side of the search track within two points.
- There is a need for immediate coverage of one end of the search area.

This coverage is followed immediately by rapid advancement of successive search legs along the line. Rectangular and elongated are the two forms of the creeping line pattern. For each form, the starting point is located (½ x S) inside the corner of the search area.

Successive long search legs use track spacing assigned by the incident commander or planner, while the short legs may be flown to within one-half that spacing of the search area's edge.

11.5 Expanding square search

Search planners rarely use the expanding square search pattern. It is designed for use when the search area is small and the position of the survivors is known within close limits (less than 20 square miles). This pattern requires precise navigation.

Usually the first leg is flown directly into the wind to minimize navigation errors. This pattern is referred to, at times, as the expanding square because it begins at an initially reported position and expands outward in concentric squares. If error is expected in locating the reported position, or if the target were moving, the square pattern may be modified to an expanding rectangle with the longer legs running in the direction of the target's reported, or probable, movement.

To minimize navigational errors due to wind drift, the first leg may be flown directly into or directly with the wind. Every other leg will thus be affected by cross wind that might blow the search aircraft off course.

In light or no wind conditions, it's often helpful to orient the expanding square pattern along the cardinal headings, that is, a direct northbound leg, followed by eastbound, then southbound and westbound legs. Length and width of the pattern may be modified to suit the requirements and conditions of the individual search.

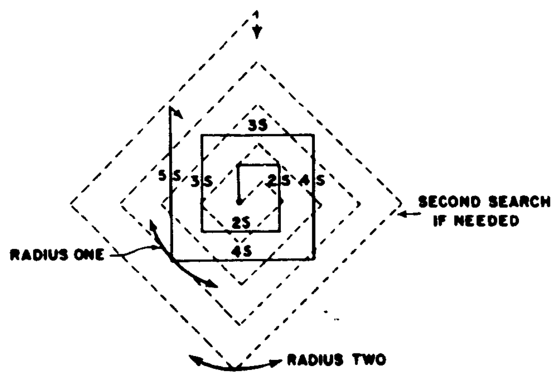


Figure 11-5

If the results of the first expanding square search are negative, and the pattern must be flown a second time over the same area, it's helpful to skew the pattern 45° to the initial orientation. This increases the likelihood of locating an objective already once missed. The second search should begin at the same starting point as the first did, but the first leg of the second search is flown diagonally to the first leg of the first search. The entire second search pattern will diagonally overlie the first.

The bold, unbroken line in Figure 11-5 illustrates the first search and the dashed line represents the second. Track spacing is "cumulative," showing the total width of the search pattern at a given point on that leg. Actual distance on a given leg from the preceding leg on the same side of the pattern is still only one 'S'. The second search of the area should begin at the same point as the first search.

11.6 Sector search

The sector search is another visual search pattern that can be used after the approximate location of the target is known. This pattern should be planned on the ground because it involves multiple headings and precise leg lengths. The pilot will fly over the suspected location and out far enough to make a turn, fly a leg that is equal to the maximum track spacing, then turn back to fly over the point again. This pattern continues until the point has been crossed from all the angles as shown in Figure 11-6.

The sector search has several advantages:

- it provides concentrated coverage near the center of the search area.
- it is easier to fly than the expanding square pattern.
- it provides the opportunity to view the suspected area from many angles, so terrain and lighting problems can be minimized.

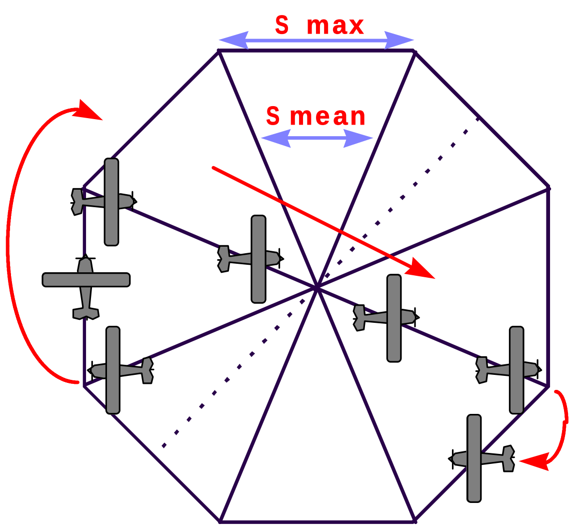


Figure 11-6

11.7 Contour search

The contour search pattern is best adapted to searches over mountainous or hilly terrain Depending upon the terrain, the search begins above the highest peak and continuously spirals downward, with each consecutive circuit usually flown 500 feet lower. While descending to a lower altitude, the pilot turns the aircraft 360 degrees in the direction opposite to the search pattern. As an alternative, the search may be flown the length of a ridge, reversing direction and descending at either end. Both options are depicted in Figure 11-7.

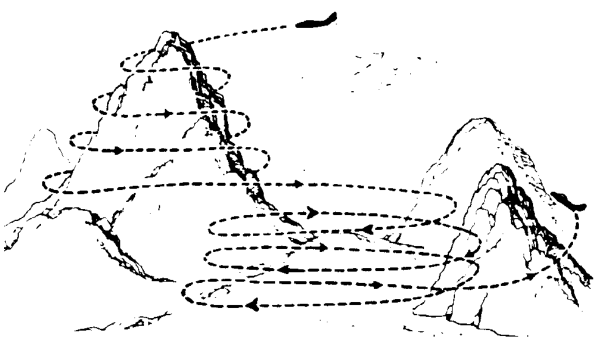


Figure 11-7

As you may have already gathered, the contour search pattern can be dangerous (see Chapter 9). The following are some helpful measures to be keep in mind before and during a contour search:

- The crew should be experienced in flying contour searches, well briefed on the mission procedures, and have accurate, large scale maps indicating the contour lines of the terrain. The pilot must be qualified and current in CAP mountain flying.
- Weather conditions should be good with respect to visibility.
- Wind gusts should be minimal to nonexistent.
- The search aircraft should be maneuverable with a steep climbing rate (i.e., high-powered aircraft) and capable of making small turning circles.
- The search should be started above the highest peak of the terrain.

Valleys and canyons also pose problems during contour searches. The search crew should highlight or mark all features that pose possible hazards to contour searching. If any crew member senses that further flight may put the search airplane in a situation where it can neither turn around nor climb out of a valley or canyon, the aircraft must not proceed any further. Crewmembers must also stay alert for wires and power lines that may cross a canyon or valley significantly above its floor. If required to fly through canyons, fly *down* the canyon so that the canyon mouth provides a safe way out. The crew should always exercise extreme caution, mark hazards or problem areas on the chart, and report them to the mission planner or debriefing officer.

As an observer on a contour search mission, you should keep an accurate record of the areas searched. Since some areas will be shrouded in fog or clouds, you will have to search those areas when weather conditions permit. One method of making such a record is to shade areas on the chart as each area is searched, as illustrated in Figure 11-8. The areas that are not shaded are those areas that cannot or have not been searched, and must be searched when conditions permit.

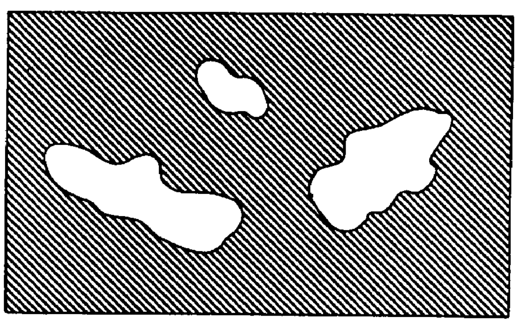


Figure 11-8

11.8 Using the GPS to fly search patterns

The GPS and LORAN were introduced in Chapter 7. This section will examine GPS features (LORAN features are very similar), and discuss ways to use them while flying search patterns.

Methods of building flight plans, identifying points, and entering and retrieving information vary by model and manufacturer, and this discussion will be limited to the most general features. The operating handbook for each GPS should be studied thoroughly for similarities to and differences from the discussion to follow.

Here's some basic terminology:

Cross track - This is the number of nautical miles left or right of a course programmed into the GPS. Some manufacturers call this *track error.*

Distance to go - The number of miles remaining to the next turn point in the programmed sequence.

Waypoints - Designations for the departure point, destination, and all intermediate or turn points for a given route when storing them in GPS memory.

Imagine you are assigned to fly the track crawl from Point A to Point B in Figure 11-1. The planner has selected two-mile track spacing for the search. You can store the two points' lat/long coordinates as user-defined waypoints in the GPS database (e.g., RCS01 to RCS02). If you select a course of "RCS01 to RCS02," the GPS will display the direct course (heading) from Point A to Point B and the CDI will show how many nautical miles the aircraft is left or right of course. If you're on course, you can turn slightly right, away from the course, until the GPS shows one mile right and then return to the planned heading (no wind), deliberately but accurately flying the leg one mile "off course." Remember that on the route search the first pass is at one-half the track spacing of the passes that will follow. If another pass is needed on the opposite side of the track, reverse the waypoint order so that the GPS will display data for the return course (RCS02 to RCS01). You can then fly one mile "off course" on the opposite side while going in the opposite direction. If a third leg is necessary, reverse the points again, and add two miles to the deliberate "off-course" distance. The next leg is then three miles right of the direct course.

It will be the pilot's job to maintain the desired "off-course" distance. Just like when keeping the DF or VOR needles centered, he will make only very slight course corrections to keep the aircraft at the desired "off course" spacing.

If the search has been narrowed, the crew may be assigned to search an area using a parallel track pattern. You sketch the search area on your sectional and then draw two points along one edge at either end of the box. Once you enter the lat/long coordinates of the two points as waypoints, you will be able to accurately fly the first leg along the edge of the area. When the distance remaining reaches zero, the aircraft is at the end of the box. Confirm this by reading the chart and reverse or re-sequence the waypoints while turning around. Again, deliberately navigate "off course" at the briefed track spacing back to the opposite end of the box. Continue this exercise across the full width of the search box. This or similar techniques can be adapted to the creeping line and expanding square patterns as well.

Another very handy feature of the GPS is its ability to display your aircraft's present position in terms of latitude and longitude. Using this display, you can "fly" a particular latitude or longitude with great precision. For instance, if you have to fly a grid you just note the lat/long boundaries of the grid and fly it using present position. Present position can be used to fly almost any pattern.

If you devote an excessive amount of time "inside" with programming and switching during the search, you might miss an important visual contact or clue "outside." In fact, a feature of the GPS helps you avoid looking "inside" too much when you want to mark a sighting. All GPS units have a single button that, when pressed, stores the lat/long of the aircraft's position as a temporary waypoint. However, you must remember that the aircraft's position and the object you want to mark are not the same; you must note the direction and distance from the airplane to the target (e.g., one mile to the northeast) for greatest accuracy.

1.1.1.1.1.11 Chapter

12

12. Scanning Techniques and Sighting Characteristics Review

12.1 Scanning

Scanning is the process of investigating, examining, or checking by systematic search. In search and rescue operations, the scanner and/or observer visually searches the search area for distress signals or accident indications by using a systematic eye-movement pattern. The observer manages all scanning aboard the search aircraft by assigning an area of responsibility to each individual scanner. When the search aircraft nears the designated search area, the mission observer must ensure that all crewmembers are aware of their respective areas of responsibility and are ready to begin the visual search.

The most commonly used eye-movement pattern involves moving the eyes, and thus the field of view, laterally or vertically while pausing every three to four degrees. This pause is known as a *fixation*. This pattern should be used at a rate that covers about 10 degrees per second.

Search aircraft motion causes the field of view to continuously change, making this scanning technique most appropriate for occupants in the front seats of small aircraft. At side windows of larger aircraft, eye movements are directed away from the aircraft to the effective visibility range and then back to a point close to the aircraft's ground track. The scanner should maintain this routine to systematically cover an assigned sector. The mission observer determines when rest periods are taken, or directs other fatigue-reducing measures. Scanning patterns should be practiced often in order to maintain or increase scanning proficiency.

Your job is to concentrate on scanning for the objective within the search area. Anyone can "look," but scanning is more than just looking. Scanning is the skill of seeing by looking in a methodical way, and there are certain techniques that can help you develop this skill. In this section, we will review these techniques. Remember, like any skill, you need to practice at using the techniques so that your ability to scan remains sharp.

12.2 Vision

Span of Vision

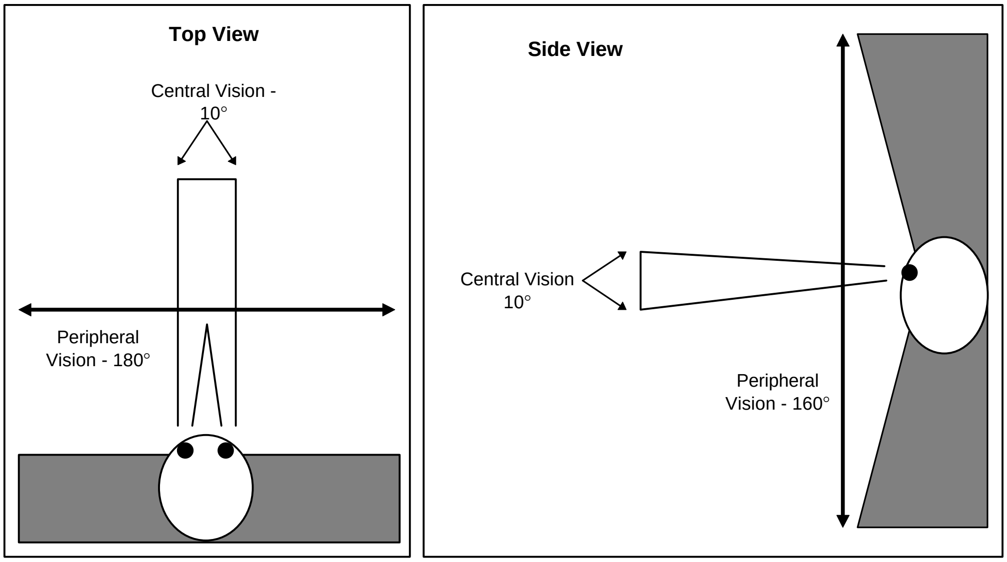


Figure 12-1

The primary tool of the scanner is his eyes. Although an eye is a marvelous device, it has some limitations even when it is in perfect physical condition (which occurs at about ten years of age and degrades steadily thereafter). There also is the problem of interpreting correctly what the eyes convey to the brain.

When a person with normal eyes looks straight ahead at a fixed point, much more than just the point is seen. The brain actively senses and is aware of everything from the point outward to form a circle of 10 degrees. This is central vision, and it is made possible by special cells in the fovea portion of the retina. Whatever is outside the central vision circle also is "picked up" by the eyes and conveyed to the brain, but it is not perceived clearly. This larger area is called peripheral vision; it is produced by cells less sensitive than those in the fovea. However, objects within the peripheral vision area can be recognized if mental attention is directed to them. Figure 12-1 shows the span of human vision.

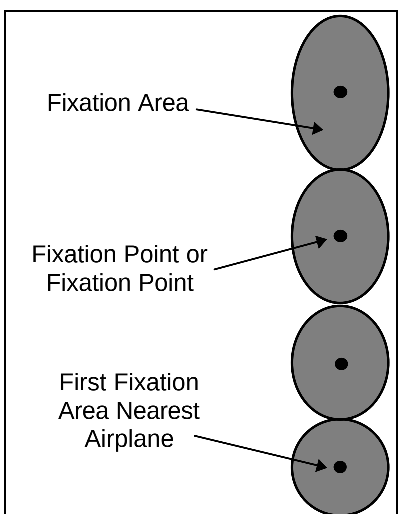


Figure 12-2

The fixation area is the area in which "concentrated looking" takes place. If the search objective happens to come within this fixation area, you probably will recognize it. It is possible to miss a search object even if it is in the fixation area because there are other factors such as fatigue and weather that also influence whether the objective will be recognized.

For central vision to be effective the eye must be focused properly, and focusing takes place each time the eyes are moved. Also, good central vision requires that the eyes be directed straight to the front. Looking sideways, in other words, can reduce the effectiveness of central vision. Why? Very simply, the nose gets in the way. Take a moment and focus on an object well to your right, but keep your head straight. Now close your right eye. See how your nose reduced your vision? These are the reasons why scanners should move their heads while scanning.

12.3 Fixation Points and Line of Scan

When you wish to scan a large area your eyes must move from one point to another, stopping at each point long enough to focus clearly. Each of these points is a fixation point. When the fixation points are close enough, the central vision areas will touch or overlap slightly. Spacing of fixation points should be three or four degrees apart to ensure the coverage will be complete (Figure 12-2). Consciously moving the fixation points along an imaginary straight line produces a band of effective "seeing."

The fist held at arm's length approximates the area of central vision, and you can use this fact to help you practice your scanning technique. Extend your arm at eye level and picture that you are looking through the back of your fist. Look "through" your fist and focus your eyes on the center of the area that would be covered if you were looking at it instead of through your fist. Now move your fist to the right to a position next to and touching the previous area (refer to Figure 12-4). Again, look "through" your fist and focus on the center of the fist-sized area on the other side of your fist. If you continue to move your fist along a line, stopping and focusing your eyes on the center of each adjacent fist-sized area, you will have seen effectively all of the objects along and near that line. You will have "scanned" the line.

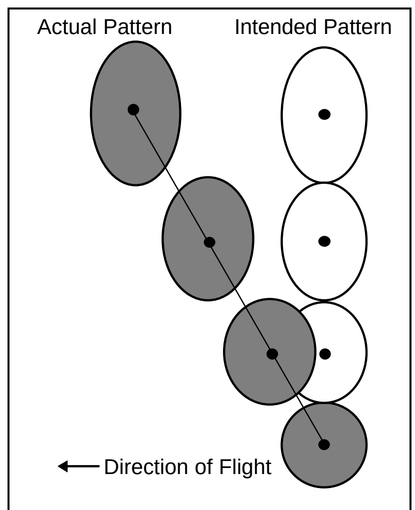


Figure 12-3

Repeat this process, but this time establish starting and stopping points for the line of scan. Pick out an object on the left as the starting point and an object on the right as the stopping point. Start with the object on the left. Extend your arm and look through your fist at that object. As practiced before, continue moving your fist to the next position along an imaginary line between the objects. Remember to stop briefly and focus your eyes. When your eyes reach the object on the right, you will have scanned the distance between the objects.

Follow the same procedure but scan between the two objects without using your fist as a guide. Move your head and eyes to each fixation point as before. Pause just long enough to focus clearly (about 1/3 second). When you reach the object on the right you will have *scanned* the line or area between the two objects and you will have scanned the line in a professional manner.

12.3.1 Fixation area

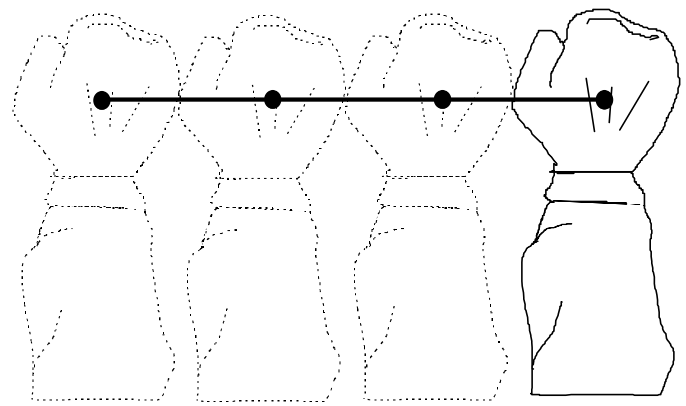


Figure 12-4

The goal of scanning techniques is to thoroughly cover an assigned search area. Reaching this goal on a single overflight is not possible for a number of reasons. First, the eye's fixation area is a circle and the search area surface (ground) is flat. Coverage of a flat surface with circles requires much overlapping of the circles. This overlapping is not possible on a search mission because of the aircraft's motion. Also, the surface area covered by the eye's fixation area is less for the area near the airplane and increases with distance from the airplane. The net result is relatively large gaps in coverage near the airplane and some overlap as distance from the airplane increases. Figure 12-2 is not to scale, but it gives a good idea of how these gaps and overlaps occur. Notice how the surface area covered begins as a relatively small circle near the airplane and takes an increasingly larger and more elliptical shape farther out. Also, Figure 12-3 shows how the forward motion of the aircraft may affect this coverage pattern. You should be aware of this affect and not allow it to cause major gaps in your scanning pattern coverage.

Angular displacement is the angle formed from a point almost beneath the airplane outward to the scanning range, or beyond. By this definition, the horizon would be at 90 degrees displacement. Although the fixation area may be a constant 10-degree diameter circle, the effectiveness of sighting the objective decrease with an increase in this angular displacement. Said another way, your ability to see detail will be excellent at a point near the aircraft, but will decrease as the angular displacement increases. At the scanning range, at which the angular displacement may be as much as 45 degrees, the resolution of detail area probably will have shrunk to a 4-degree diameter circle.

12.3.2 Field of scan

The area that you will search with your eyes in lines of scan is called the field of scan. The upper limit of this field is the line that forms the scanning range. The lower limit is the lower edge of the aircraft window, while the aft (back) limit is usually established by the vertical edge of the aircraft window. The forward (front) limit for a field of scan will vary. It might be established by a part of the airplane (such as a wing strut). Or, when two scanners are working from the same side of the airplane, it might be limited by a pre-agreed point dividing the field of scan.

12.3.3 Scanning Range

We are using the term "scanning range" to describe the distance from an aircraft to an imaginary line parallel to the aircraft's ground track (track over the ground). This line is the maximum range at which a scanner is considered to have a good chance at sighting the search objective. Scanning range sometimes may be confused with search visibility range. Search visibility range is that distance at which an object the size of an automobile can be seen and recognized. Aircraft debris may not be as large as an automobile, and it may not be immediately recognizable from the air as parts of an airplane. Therefore, scanning range can be the same as or shorter than search visibility range.

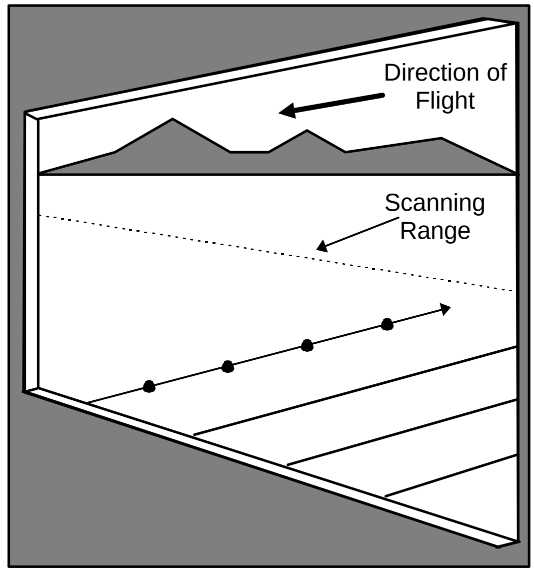


Figure 12-5

If your pilot states that the search altitude will be 500 feet above the ground level (AGL), you can expect your scanning range to be ¼ to ½ mile. If the search altitude is 1,000 feet AGL, you can expect a scanning range of between ½ and 1 mile. Even so, there are many variables that affect both the effective scanning range and your probability of detecting the search objective. These issues are discussed elsewhere in this chapter.

12.4 Scanning patterns

To cover the field of scan adequately requires that a set pattern of scan lines be used. Research into scanning techniques has shown that there are two basic patterns that provide the best coverage. These are called the *diagonal pattern* and the *vertical pattern.*

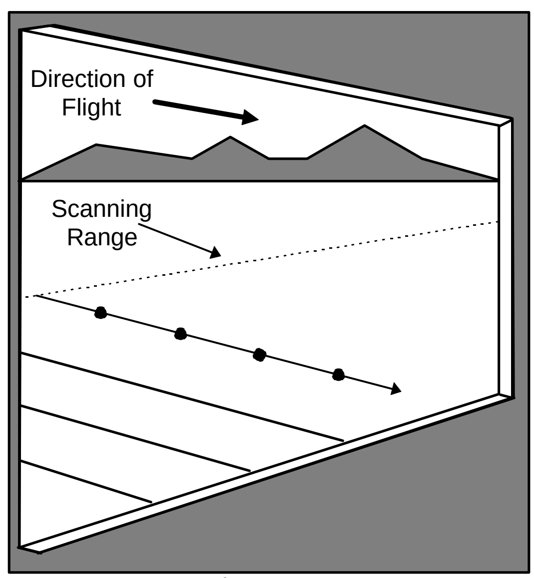


Figure 12-6

Figure 12-5 illustrates the way the diagonal pattern is used when sitting in the right rear seat of a small airplane. This line is followed from left to right as in reading. The first fixation point is slightly forward of the aircraft's position. Subsequent fixation points generally follow the line as indicated in the figure.

The next scan line should be parallel to the first, and so on. Each succeeding scan line is started as quickly as possible after completing the previous one. Remember that the duration of each fixation point along a scan line is about 1/3 second; how long it takes to complete one scan line depends on the distance at which the scanning range has been established. Also, the time required to begin a new scan line has a significant influence on how well the area nearest the airplane is scanned. In other words, more time between starting scan lines means more space between fixation points near the airplane.

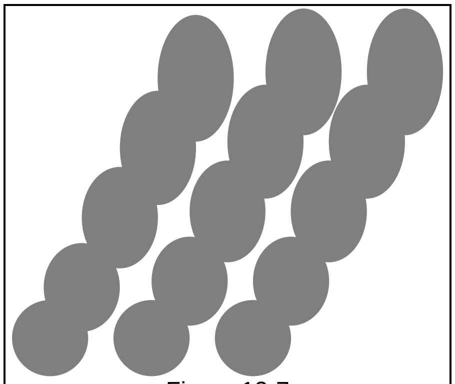


Figure 12-7

When the diagonal scanning pattern is used from the *left* rear window (Figure 12-6), the direction of scan lines still is from left to right, but each line starts at the scanning range and proceeds toward the airplane. Each scan line on this side terminates at the window's lower edge. Figure 12-7 gives you an idea of the surface coverage obtained with a diagonal scanning pattern.

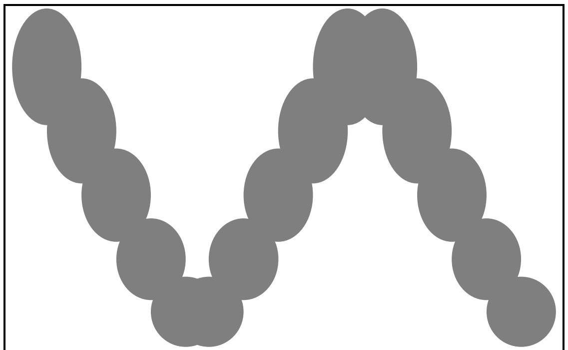


Figure 12-9

The second and somewhat less effective scanning pattern is illustrated in Figure 12-8. This pattern is vertical and is basically the same as the example shown in Figure 12-2. You should use this vertical pattern only from a rear-seat position, and the first fixation point should be as near to underneath the airplane as you can see. Subsequent fixation points for this first scan line should progress outward to the scanning range and back. Figure 12-9 reveals the sawtooth shape this vertical pattern makes on the surface. Observe how much surface area near the airplane is not covered.

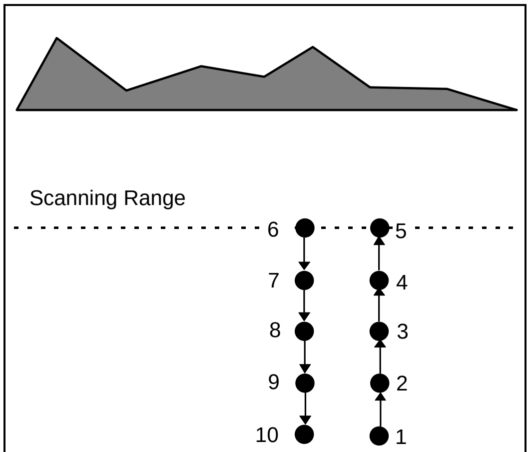


Figure 12-8

If there are two scanners on the same side of the airplane, it is good practice to combine the diagonal and vertical patterns. As agreed between scanners, one would use the diagonal pattern and the other the vertical pattern. However, the scanner using the vertical pattern *would not* scan to the scanning range. Some distance short of the scanning range would be selected as the vertical-pattern limit. This technique provides good coverage of the surface area near the search aircraft.

When flying in the right front seat of an airplane you will use the diagonal pattern. This is true because it is the only pattern that has a natural flow to it from this particular position. Because of the aircraft's structure, you probably will want to begin your scan line near the line of flight over the surface. This will be somewhat ahead of the airplane (not much). The angle of the scan line and its length will be determined by whatever structural part obstructs your vision. For example, you could use the window post on some aircraft as either a starting point or stopping point, depending on your judgment. If you are in the right front seat of a low-wing model, the wing will be the stopping point.

Scanners, especially those with considerable experience, may use a system or pattern that is different from the diagonal and vertical patterns discussed above. Many search objectives were found and many lives were saved long before there was an effort to analyze the scanning process and develop recommendations for its improvement. On the other hand, it is possible that Civil Air Patrol's outstanding search and rescue record would have been better had the scanners of times past used a set pattern and used it consistently.

12.5 Atmospheric and lighting conditions

During darkness, scanners make fewer fixations in their search patterns than during daylight because victims in distress are likely to use lights, fires, or flares to signal rescuers. Contrast between signal light and surrounding darkness eliminates the need for scanners to concentrate on making numerous eye fixations. An attentive scanner or observer should be able to see a light, flare, or fire easily during night operations. Search aircraft interior lighting should be kept to the lowest possible level that still allows normal chart reading. This will help the eyes adjust to the darkness and reduce glare on windshield and window surfaces. Red lights are used when flying at night because that color has little or no affect on the low-light adaptation of the human eye. Regardless of light conditions, a scanner should always maintain a systematic scanning pattern with fixations every few seconds. Darkness merely lengthens the interval between fixations.

12.5.1 Atmospheric conditions

All aircrews hope for perfect visibility during a SAR mission. Seldom does this atmospheric condition exist. Most of the time the atmosphere (especially the lower atmosphere) contains significant amounts of water vapor, dust, pollen, and other particles. These items block vision according to their density. Of course, the farther we try to see the more particles there are and the more difficult it is to sight the objective.

The urgency of finding a downed aircraft may require flight under marginal conditions of visibility. An example here is flight through very light rain or drizzle. Another example is flight during the summertime when the air is not moving appreciably. It may become virtually saturated with pollutants.

12.5.2 Position of the sun

Flying “into the sun” soon after it rises in the morning or before it sets in the afternoon, poses visibility problems. No doubt you have had this experience while driving or riding as a passenger in an automobile. Recall how difficult it is to distinguish colors and to detect smaller objects.

Research in search and rescue techniques has determined that the best time to fly search sorties is between mid-morning and mid-afternoon. This is when the sun is about 30 degrees or more above the horizon. When the sun is below this angle, it intensifies visibility problems.

As the sun climbs higher in the sky it helps to relieve visibility problems caused by the presence of particles in the atmosphere. The sun’s rays heat the ground and the atmosphere. This heat causes the lower atmosphere to expand. As the atmosphere expands the particles it contains are spread farther apart, decreasing their density within a given volume. Therefore, there are fewer particles between the surface and the scanner’s eyes and the effective scanning range is increased slightly.

12.5.3 Clouds and shadows

Shadows produced by clouds can reduce the effective scanning range. This is due to the high contrast between sunlit area and shadows. Our eyes have difficulty adjusting to such contrasts. The same effect occurs in mountainous areas where bright sunlight causes the hills and mountains to cast dark shadows.

12.5.4 Terrain and ground cover

If flat, open, dry areas were the only areas to be searched, the scanner’s job would be easy. Most aircraft crashes do not happen in such areas; when one does happen, it usually is found quickly without an intensive search effort.

The more intensive search efforts occur over terrain that is either mountainous or covered with dense vegetation, or both. Mountainous area searches demand frequent variation in the scanning range. This you can visualize fairly easily; at one moment the mountain or hill places the surface within, say 200 feet of the aircraft. Upon flying past the mountain or hill the surface suddenly may be a half-mile away.

Forested areas can reduce the effective scanning range dramatically. This is especially true during spring, summer, and fall when foliage is most pronounced. The situation doesn’t change for the better in the winter where trees are of the evergreen type (e.g., pine and spruce) because the height of the trees plus their foliage masks the search objective very effectively. Frequently the only way for a scanner to actually spot an objective under such circumstance is to be looking down almost vertically. There are other signs to look for in such areas, but we will discuss them later.

12.5.5 Surface conditions

Here we are thinking of snow, primarily. Even a thin covering of new snow will change the contour, or shape, of a search objective. Also, the light-reflective quality of snow affects visual effectiveness. The net result is a need to bring the scanning range nearer to the aircraft.

12.5.6 Cleanliness of window

This might seem to be a very minor factor. On the other hand, it is estimated that the scanner's visibility can be reduced up to 50 percent if the aircraft window isn't clean. If you discover this to be the case in your aircraft, clean the window yourself. Aircraft windows are made of plastic and easily scratched, so it is important to use the proper cleaning materials. A supply should be kept in all CAP aircraft for just this purpose.

12.5.7 Condition of the scanner

Your general physical welfare will influence how well you do your job. For example, if you have a cold or sinus trouble you may feel so bad you cannot concentrate on scanning. In effect, this reduces your personal effective scanning range to "zero." Only you can determine your fitness to fly and do the job expected of you. If you do not believe that you feel up to the job at the moment, ask for a non-flying assignment. You will be more highly regarded if you know your own limits.

Our discussion of variables could be extended considerably because most anything that happens during a sortie could affect the scanning operation. However, the variables of major importance have been discussed.

12.6 Visual clues

12.6.1 Sighting Characteristics

Objects appear quite different when they are seen from above and at a greater distance than usual. We will review some visual clues, what you might expect in aircraft wreckage patterns, signals which survivors might be expected to use, and some false clues which are common to selected areas.

12.6.2 Typical Visual Clues

Anything that appears to be out of the ordinary should be considered a clue to the location of the search objective. In addition to this piece of advice, the following are specific clues for which scanners should be looking:

Light colored or shiny objects - Virtually all aircraft have white or other light colors as part of their paint schemes. Some aircraft have polished aluminum surfaces that provide contrast with the usual ground surface features. Also, bright sunlight will "flash" from aluminum surfaces.

Aircraft windshields and windows, like aluminum, have a reflective quality about them. If the angle of the sun is just right, you will pick up momentary flashes with either your central or peripheral vision. A flash from any angle deserves further investigation.

Smoke and fire - Sometimes aircraft catch fire when they crash. If conditions are right, the burning airplane may cause forest or grass fires. Survivors of a crash may build a fire to warm themselves or to signal search aircraft. Campers, hunters, and fishermen build fires for their purposes, but no matter what the origin or purpose of smoke and fire, each case should be investigated.

Blackened areas - Fire causes blackened areas. You may have to check many such areas, but finding the search objective will make the effort worthwhile.

Broken tree branches - If an airplane goes down in a heavily wooded area, it will break tree branches and perhaps trees. The extent of this breakage will depend on the angle at which the trees were struck. The primary clue for the scanner, however, will be color. As you no doubt realize, the interior of a tree trunk or branch and the undersides of many types of leaves are light in color. This contrast between the light color and the darker foliage serves as a good clue.

Local discoloration of foliage - Here we are talking about dead or dying leaves and needles of evergreen trees. A crash that is several days old may have discolored a small area in the forest canopy. This discoloration could be the result of either a small fire or broken tree branches.

Fresh bare earth - An aircraft striking the ground at any angle will disturb or "plow" the earth to some degree. An overflight within a day or so of the event should provide a clue for scanners. Because of its moisture content, fresh bare earth has a different color and texture than the surrounding, undisturbed earth.

Breaks in cultivated field patterns - Crop farmlands always display a pattern of some type, especially during the growing season. Any disruption of such a pattern should be investigated. A crop such as corn could mask the presence of small aircraft wreckage. Yet the pattern made by the crashing airplane will stand out as a break in uniformity.

Water and snow - Water and snow are not visual clues, but they often contain such clues. For example, when an aircraft goes down in water its fuel and probably some oil will rise to the water's surface making an "oil slick" discoloration. Other material in the aircraft may also discolor the water or float as debris. If the aircraft hasn't been under the water very long, air bubbles will disturb the surface. Snow readily shows clues. Any discoloration caused by fire, fuel or debris will be very evident. On the other hand, do not expect easy-to-see clues if snow has fallen since the aircraft was reported missing.

Tracks and signals - Any line of apparent human tracks through snow, grass, or sand should be regarded as possibly those of survivors. Such tracks may belong to hunters, but it pays to follow them until the individual is found or you are satisfied with their termination-at a road, for example. If you do find the originator of such tracks and the person is a survivor, no doubt he will try to signal. More than likely this signal will be a frantic waving of arms.

Birds and animals - Scavenger birds (such as vultures and crows), wolves, and bears may gather at or near a crash site. Vultures (or Buzzards) sense the critical condition of an injured person and gather nearby to await the person's death. If you see these birds or animals in a group, search the area thoroughly.

False clues - In addition to the false clues of camp fires and other purposely set fires, there are others of which you should be aware; oil slicks may have been caused by spillage from ships. All aircraft parts may not have been removed from other crash sites. Some of the aircraft parts may have been marked (with a yellow "X"), but you may not be able to see the mark until near the site because the paint has faded or worn off with age.

In certain parts of the country, you will encounter many false clues where you would not ordinarily expect to see them. These false clues are discarded refrigerators, stoves, vehicles and pieces of other metal, such as tin roofing. What makes these false clues unique is that they are in areas far from towns and cities.

Survivors and Signals - If there are survivors and if they are capable of doing so, they will attempt to signal you. The type of signal the survivors use will depend on how much they know about the process and what type signaling devices are available to them. Here are some signaling techniques that survivors might use:

- A fire - Most people carry some means of starting a fire. And a fire probably will be the survivor's first attempt at signaling. The smoke and or flames of a fire are easily seen from the air, as we pointed out earlier.
- A group of three fires.
- Three fires forming a triangle is an international distress signal.
- Red smoke, white smoke, or orange smoke.
- Colored smoke is discharged by some types of signaling devices, such as flares. Other flares are rocket types; some send up a small parachute to which a magnesium flare is attached.
- Signal mirrors - If the sun is shining, a signal mirror is the most effective signaling device. A special survival signal mirror includes instructions to the survivor on how to aim the signal at the search aircraft. Pocket mirrors will also work but aiming them may not be as easy.
- Panels on the ground - This type signal can be formed with white panels or with colored panels especially designed for the purpose. Of course, survivors may be able to arrange aircraft parts as a signal.

Messages - There are a number of methods and materials which survivors can use to construct messages. In snow, sand, and grassy areas, survivors may use their feet to stamp out simple messages, such as HELP or SOS. More than likely such messages will be formed with rocks, tree branches, driftwood, or any other similar materials. Such materials may also be used to construct standard ground-to-air signals. These signals are familiar to military and professional civilian pilots, including CAP pilots. Ground-to-air signals are normally carried in CAP aircraft for reference.

Nighttime signals - For various reasons, nighttime air searches are infrequent. Flights will be at 3,000 AGL or higher, and you will not need to use the scanning patterns discussed earlier.

A fire or perhaps a flashlight will be the survivor's means of signaling. On the other hand, a light signal need not be very bright; one survivor used the flint spark of his cigarette lighter as a signal; his signal was seen and he was rescued.

12.7 *Wreckage patterns (accident signs)*

Frequently, there are signs near a crash sight that the aircrew can use to locate the actual wreckage. The environment plays a major role in sighting the signs from the search aircraft. In crashes at sea, searchers may be unable to locate the crash site as rough seas can scatter wreckage or signs quickly. On land, the wreckage may be in dense foliage, which can obscure it in a matter of days. By knowing signs to look for, the scanner can improve the effectiveness of each sortie.

Common signs of accidents include:

- light colored or shiny objects.
- sunlight reflected off metal.
- people.
- distress signals.
- blackened or burned areas.
- broken tree branches.
- fresh or bare earth.
- discolored water or snow.
- tracks or movement patterns in snow, grass, and sand.
- excessive bubbles in water.
- oil slicks, floating debris, or rafts on water.
- smoke.
- deep furrows in fields or snow.
- abnormalities in the environment.

In general, don't expect to find anything that resembles an aircraft; most wrecks look like hastily discarded trash. However, certain patterns do result from the manner in which the accident occurred. These patterns are described as:

12.7.1 Hole in the ground

Caused from steep dives into the ground or from flying straight into steep hillsides or canyon walls. Wreckage is confined to a small circular area around a deep, high-walled, narrow crater. The structure may be completely demolished with parts of the wings and empennage near the edge of the crater. Vertical dives into heavily wooded terrain will sometimes cause very little damage to the surrounding foliage, and sometimes only a day or two is needed for the foliage to repair itself.

12.7.2 Cork screw or auger

Caused from uncontrolled spins. Wreckage is considerably broken in a small area. There are curved ground scars around a shallow crater. One wing is more heavily damaged and the fuselage is broken in several places with the tail forward in the direction of the spin. In wooded areas, damage to branches and foliage is considerable, but is confined to a small area.

12.7.3 Creaming or smear

Caused from low-level "buzzing", or "flat hatting" from instrument flight, or attempted crash landing. The wreckage distribution is long and narrow with heavier components farthest away from the initial point of impact. The tail and wings remain fairly intact and sheared off close to the point of impact. With power on or a windmilling propeller, there is a short series of prop bites in the ground. Ground looping sometimes terminates the wreckage pattern with a sharp hook and may reverse the position of some wreckage components. Skipping is also quite common in open, flat terrain. In wooded areas, damage to the trees is considerable at the point of impact, but the wreckage travels among the trees beneath the foliage for a greater distance and may not be visible from the air.

12.7.4 The Four Winds

Caused from mid-air collisions, explosion, or in-flight break up. Wreckage components are broken up and scattered over a wide area along the flight path. The impact areas are small but chances of sighting them are increased by the large number of them. Extensive ground search is required to locate all components.

12.7.5 Hedge-trimming

If an aircraft strikes a high mountain ridge or obstruction but continues on for a considerable distance before crashing. Trees or the obstruction are slightly damaged or the ground on the crest is lightly scarred. Some wreckage components may be dislodged; usually landing gear, external fuel tanks, cockpit canopy, or control surfaces. The direction of flight from the hedge-trimming will aid in further search for the main scene.

12.7.6 Splash

Where an aircraft has gone down into water, oil slicks, foam, and small bits of floating debris are apparent for a few hours after the impact. With time, the foam dissipates, the oil slicks spread and streak, and the debris become widely separated due to action of wind and currents. Sometimes emergency life rafts are ejected but, unless manned by survivors, will drift very rapidly with the wind. Oil slicks appear as smooth, slightly discolored areas on the surface and are in evidence for several hours after a splash; however, they are also caused by ships pumping their bilges and by offshore oil wells or natural oil seepage. Most aircraft sink very rapidly after ditching.

12.8 Reducing fatigue effects

The art of scanning is more physically demanding and requires greater concentration than mere sight seeing. In order to maintain the effectiveness of all scanning crewmembers, an observer must be aware of his own fatigue level, and that of the scanner or scanners. The following tips can help the observer direct appropriate actions and maintain scanning effectiveness:

- Change scanning positions at 30- to 60-minute intervals, if aircraft size permits.
- Rotate scanners from one side of the aircraft to the other, if two or more scanners are present.
- Find a comfortable position, and move around to stretch when necessary.
- Clean aircraft windshields and windows. Dirty windows accelerate onset of eye fatigue, and can reduce visibility by up to 50 percent.
- Scan through open hatches whenever feasible.
- At night, use red lights and keep them dimmed to reduce reflection and glare.
- Use binoculars to check sightings made first by the naked eye.
- Focus on a close object (like the wing tip) on a regular basis. The muscles of the eye get tired when you focus far away for and extended period of time.

1.1.1.1.1.12 Chapter

13

13. Flight Planning

13.1 Time conversion

When traveling and communicating over large distances, it is important to use a standard time reference. Without such a reference, imagine the difficulties involved if you want to plan another hypothetical flight, this time from Phoenix, Arizona, to Maxwell Air Force Base, Alabama. When checking the Notices to Airmen (NOTAMs), you find that Maxwell is closed until 1200. What time should you leave Phoenix so that you don't arrive at Maxwell before the airport opens? If the hypothetical airplane could fly such a trip in six hours, would you want to leave Phoenix at 6:00? The answer in this case is "no".

The first question in making such a determination would probably be: "Does Maxwell open at 12:00 *noon* or 12:00 *midnight*?" To immediately eliminate such confusion, all times used in aviation use the 24-hour "military" clock. In the 24-hour clock, midnight is identified as 0000 and the morning hours are then numbered normally up to the noon hour or 1200. Continuing into the afternoon, 1:00 p.m. is identified as 1300, 2:00 p.m. is 1400, 3:00 p.m. is 1500, and so on through 11:59 p.m. or 2359. At midnight, the designations start over again at 0000.

Another flight planning question in this case is: "Maxwell opens at 1200. Is that Central Time, the time zone where Maxwell is located or Mountain Time where Phoenix is located?" To further complicate matters, it is not clear whether that is standard time, or daylight-saving time. Maxwell uses daylight-saving time in the summer like most of the rest of the country, but Phoenix doesn't. You may recall from the discussion of latitudes and longitudes that there are 360 meridians of longitude on the earth's surface. The numbering for them starts at the prime or 0° meridian that passes through Greenwich, England. To bring uniformity and a standard reference to time designation, all time references are based on Coordinated Universal Time (UTC), *Greenwich Mean Time* (GMT), or *Zulu* time.

When you see that Maxwell is closed until 1200*Z* that means Maxwell is closed until its 1200 noon in Greenwich, England. To arrive at Maxwell right as the airfield opens, you should depart Phoenix on your six-hour flight when it's 0600 in Greenwich, England. You can then convert that Zulu time to Phoenix local time by adding or subtracting the number of hours that are appropriate to the Phoenix time zone.

Figure 13-1 shows part of the first two lines of the Phoenix-Sky Harbor International Airport entry from the Southwest Volume of the Airport/Facility Directory. You know from your earlier calculation that you want to depart Phoenix at 0600 Greenwich Mean Time to arrive at Maxwell at 1200Z.

Use the conversion factor, UTC -7, from line 1 of the Phoenix Sky Harbor entry and subtract it, since it has a minus sign, from 0600. This reveals your departure time would be at 2300 local time or 11:00 p.m. the night before. Airports in states that use daylight-saving time are indicated in the facility directory with daylight-saving time to UTC conversion factors shown in parentheses.

If you don't really care what time you will arrive at Maxwell and want to depart Sky Harbor at 8:00 a.m., you still must determine the *Zulu* departure time for the pilot to include on the flight plan he'll file with the FAA. In this case, convert from local to Zulu or Greenwich Mean Time by reversing the minus sign in the conversion factor, UTC -7, and adding seven to the 8:00 proposed departure time. The departure time is written on the flight plan as 1500*Z*. Maxwell would expect you to arrive six hours later, at 2100Z.

PHOENIX SKY HARBOR INTL	(PHX)	3E	**UTC -7**	33°26.17'N 112°00.57'W
1133 B S4	FUEL 100LL, JET-A			

KILL DEVIL HILLS	(FFA)	3E	**UTC -5 (-4 DT)**	N36°01.09' W75°40.28'
13 TPA-813(800)				

Figure 13-1

13.2 The Flight Plan

A flight plan (CAPF 104 or 84) is required for each sortie flown by your aircrew. This flight plan is the pilot's responsibility; it amounts to a before-and-after record of the total flight. You will not have anything to contribute to the flight plan document other than your name, but your observations may become part of it after the sortie.

Your pilot must consider many things as he fills out the flight plan. The primary purpose of a flight plan is to let mission headquarters know where your aircraft is going and when it will return. Thus, the route of flight and estimated time of arrival (return) is of utmost importance. If an airplane isn't back within a reasonable time past the pilot's estimated time of return, a search will be started. Thus, it is possible to have a "search within a search."

Determining how long it will take to fly to the search area, conduct the search, and return requires thorough planning. As an observer, you are encouraged to assist the pilot in planning the flight.

For flights greater than 50 nm away from your base, CAP requires the pilot to file a FAA flight plan in addition to the CAP flight plan.

13.3 IFR and VFR flight rules

Imagine a highway system where the roads have no stoplights, stop signs, edge boundaries, centerline markings, or direction signs, and where there are no one-way streets and no police to direct traffic. The skies would truly be a hazardous environment if procedures and rules did not exist to bring order to what would otherwise be anarchy. The Federal Aviation Administration (FAA) is the executive agency tasked with developing rules and procedures for aircraft operators, managing the system, and enforcing the rules and procedures. Bringing order and safety to millions of daily flights in the United States is the responsibility of the FAA's air traffic control facilities, frequently abbreviated as ATC.

The FAA has developed visual flight rules (VFR) and instrument flight rules (IFR) to govern the activities of pilots and controllers. When the pilot files a flight plan under visual flight rules, or VFR, he assumes <u>complete</u> responsibility for seeing and avoiding all other aircraft. Operations under VFR can only be conducted if the visibility is at least 3 statute miles ***and***, if the sky is more than one-half covered by clouds, the bases of those clouds must be no lower than 1,000 feet above the surface. Also, the pilot must stay away from clouds by at least 2,000 feet horizontally, or remain either 1,000 feet above, or 500 feet below the clouds. There are exceptions to these rules, but for the present purpose, these conditions normally apply. Because the pilot takes responsibility for seeing and avoiding all other aircraft, communication requirements are significantly less complicated than when he chooses to operate under IFR.

Under instrument flight rules (IFR) the pilot enters into a partnership with the air traffic controller. Within that partnership, the controller has responsibility for using his radar to maintain safe separation between *all* aircraft that are operating under instrument flight rules, and between IFR and participating VFR aircraft. Participating VFR aircraft are those VFR aircraft that are provided separation service by the controller either because the pilot has requested it, or FAA regulations for the category of airspace in which the flight is conducted require it.

When aircraft operate under IFR, they must all follow pre-approved flight paths so the controller can maintain separation. Aircraft operating under IFR cannot make changes in altitude or course without permission from the controller. Receiving permission is known as receiving a "clearance".

Flight under IFR is inherently inflexible and usually not practical when conducting visual searches. The rules and limitations in radar system capabilities may prevent radar (or communications) coverage of flights in the 500 to 1500 foot AGL search altitude range, making visual searches under IFR unsuitable. Electronic searches may be conducted at higher altitudes, and selection of IFR *may* be appropriate when considering all the circumstances and urgency of the situation. Instrument flight rules also require the pilot to be specially trained and certified to control the airplane by referencing only the airplane’s instruments. Additionally, the aircraft itself must be certified for IFR flight (CAP aircraft are required to maintain this certification).

It's important to understand that IFR and VFR are different sets of <u>rules</u> with which the pilot must comply. Even though the weather may be clear with no restrictions to visibility, if a flight is operated under IFR all the communication and coordination requirements still apply.

13.4 Briefings

13.4.1 General

Formal and complete briefings and debriefings are essential to a safe and effective mission. They must be comprehensive, but concise and specific. Inadequate briefings may lead to complacency and compromise both the mission and safety. Briefings and debriefings should be conducted in a formal atmosphere and in a suitable briefing room. Professionalism and compliance with directives will be stressed. Detailed checklists should be used to prevent omission of important data. Briefings also must be scheduled to allow crews ample time for pre-departure activities. The briefing will set the tone for mission accomplishment.

13.4.2 General Briefing

A general group briefing is normally presented at the beginning of the mission and updated as necessary. The briefing (usually following CAPF 102) should present important information and bring aircrews and ground teams up-to-date on developments in the mission. Personnel must be kept fully informed of operational plans and the status of the mission so that individual aircrews and ground teams may make sound decisions and assist in providing information to the IC/MC.

13.4.3 Aircrew and Ground Team Briefings

In addition to the requirement for a general mission briefing, each aircrew and ground team will be given a detailed briefing prior to each sortie. This will include the type of mission, areas to be covered, assigned altitudes, search patterns, communications frequencies and procedures, actions to be taken if the objective is located, hazards to operations, and other pertinent information. Individual briefing folders should be prepared for each aircrew and ground team. Aircrew briefing kits, which are maintained by each Mission Pilot, should contain:

- CAP Form 104, Mission Flight Plan/Briefing.
- CAPR 55-1, CAP Emergency Services Mission Procedures.
- Appropriately gridded sectional charts (should be prepared on a permanent basis). Current charts must be used for navigation and obstruction clearance.
- Specialized briefing checklists (as applicable).
- Any other appropriate material considered necessary.

It is essential that all involved in a briefing understand what is briefed. You must ask questions if you don't understand something or want further information. It is your <u>duty</u> to receive a thorough briefing.

13.4.4 Crew and Passenger Briefings

Prior to each flight, the pilot in command will brief the crew and passengers. This briefing will include essential information regarding the flight, such as route, weather, altitudes, duties, and specific information concerning the aircraft, such as survival equipment, emergency exits, and in-flight emergency procedures. When more than one flight is accomplished by the same crew and passengers during the day, subsequent briefings are not required in their entirety but must at a minimum highlight differences and changes from the original briefing.

13.4.5 Debriefings

Debriefings serve to collect and record information from each sortie. This information is then collated and evaluated by mission staff. The results of each sortie effect all successive activities.

An aircrew or ground team cannot search with "negative results". Even if the objective is not located, important information is obtained (e.g., weather, ground cover, and other factors affecting search visibility and effectiveness).

Aircrews enter mission data and write their comments on the reverse of the CAPF 104 after each sortie. The debriefer reviews this during the debriefing and may then ask the crew for additional information.

The most important information a search aircrew or ground team can provide is what was searched and how effective the search was. The CAPF 104 requires the crew to rate crew and SAR effectiveness. Factors such as the weather, terrain, time of day, turbulence, shadows, ground coverage, and visibility must be considered. Debriefing results are provided to the operations and planning staff periodically or whenever significant items are evident. At the end of operational period, the IC/MC and mission staff use the debriefing forms to update the search status, compile probability of detection, and determine priorities for the next period's activities.

It is absolutely essential that the information you give the debriefer is accurate and thorough. You must be brutally honest about what you saw or what you think you may have missed, how much time you spent looking inside the aircraft, how you felt during the search, what areas you think may need to be searched again, and the like. The mission staff and the IC/MC depend upon this information to judge the progress of the mission and to determine future plans. If you think crew and SAR effectiveness were excellent (if it was there we would have seen it), say so. If you have any doubts, express them.

13.4.6 Form 104

The front of the CAPF 104, Mission Flight Plan/Briefing Form, is primarily the pilot's responsibility. The reverse side of the form is crew’s responsibility and is very important to the debriefer.

The debriefer uses the information on the reverse side of the Form 104 as a starting point for the debriefing. For example, more information on search area weather conditions may be needed, and you should be ready to volunteer your observations. Perhaps you noticed an increase in cloud shadows. Perhaps visibility seemed to deteriorate because of haze that developed after your team arrived in the search area. Any number of factors could have changed while you were in the search area. To make the best contribution to the debriefing requires that you remember these details and be prepared to tell the debriefer about them. This is why it is so important that you keep a log of each sortie.

We cannot predict exactly what your debriefer will ask because each debriefer has her own method of doing the job. Debriefers are expected to gather information about specific events and conditions encountered during the sortie. Here are some examples of questions you may be asked by the debriefer:

Did you notice anything, which might be hazardous?

The debriefer wants you to think back to everything that happened during the sortie. For example, see if you can remember anything on the flight line that seemed to be an unsafe practice. If you saw flocks of birds anywhere during the flight, say so and try to remember where they were. Birds pose a special hazard to aircraft and the larger the bird the more trouble it can make. This is particularly true of geese, ducks and egrets.

Although you may not be sure that a condition or event posed a hazard, do not hesitate to volunteer your concerns. No one is going to laugh at a “stupid” remark -- all information is important.

Did you make any changes to the planned search procedure?

One of the debriefer's primary interests is determining whether you searched your assigned area(s). If, for example, your crew diverted frequently to examine clues, there is a good possibility that search coverage was not adequate and another sortie may be justified. If you became excessively tired and rested your eyes frequently, the debriefer needs to know.

What types of clues did you investigate?

The debriefer needs to know what clues you investigated and those you deemed unimportant. Perhaps a clue seemed so insignificant that you decided not to investigate; describe it and its location. Also, it is important to describe clues that were investigated and found to be false. Pinpoint these on the map. This information may become part of the briefing for another aircrew because it will prevent them from wasting time by investigating the same false clues.

When the debriefer is satisfied that all pertinent information has been noted you will be dismissed. Now what should you do? Obviously, you will need rest. If you are scheduled for another sortie, find someplace quite. Close your eyes. Try to sleep, if there is time to do so.

The mission normally ends when the search objective is located. At this time mission personnel will return to their homes. If the search objective has not been found but it is determined that further searching is unwarranted, the mission will be suspended. When a mission is suspended it means that it may be reopened if additional clues are received. Even so, all mission personnel return to their homes and wait for the next mission alert.

1.1.1.1.1.13 Chapter

14

14. Aircrew Coordination

Many professional studies have proven that properly trained team members can collectively perform complex tasks better and make more accurate decisions than the single best performer on the team. Conversely, the untrained team's overall performance can be significantly worse than the performance of its weakest single member. This chapter will cover aspects and attitudes of teamwork and communication among team members.

14.1 Team Concept and Communication

Until recently, the study of crew coordination principles was limited to studying flight crew performance. However, over the last decade, the number of preventable operator-caused errors leading to accidents has led both the military and commercial aviation communities to expand the study. Airline and military crew resource training now emphases and encourages the pilot or aircraft commander to include *all* assets and sources of information in the decision-making process. The general assumption is that as more information becomes available, more accurate decisions are more likely and operator errors will be reduced.

The same general principles of crew coordination and resource management apply to all the members of the search and rescue team. Incident commanders, flight planners, operations officers, pilots, mission observers, scanners, air traffic controllers, and flight service station personnel should all be considered sources for appropriate information by the air team.

In order for any information to be used, it must be effectively communicated. The effective communication process that leads to good crew coordination actually starts well before a flight begins. Each member must pay close attention during briefings. A clear understanding of the "big picture," search objective, altitudes, area assignments, and search patterns to be used *prior* to departure will preclude questions and debate in flight, when other tasks should take higher priority. Crewmembers having questions are encouraged to ask them at this time.

Search assignments and procedures should be clearly stated to the crews, and crewmembers are encouraged to offer their own ideas. Planning officers should answer each question openly and non-defensively, and you should also make every effort to seek complete understanding of each situation.

In developing the actual search mission plan, workload management and task distribution are very important. An over-tasked crewmember may not develop a complete grasp of mission aspects that later may affect his performance. Remain alert for over-tasking in other crewmembers, and offer help if possible. If you find yourself over-tasked, do not hesitate to ask another qualified member for help. Each team member must continually think “teamwork.”

Close attention should be paid during the pilot’s briefing. The pilot will establish flight-specific safety rules at this time, such as emergency duties and division of responsibilities. Each individual must again clearly understand her specific duties and responsibilities before proceeding to the aircraft.

In assigning scanning responsibilities to the scanners, mission observers must be receptive to questions and suggestions from the scanners. Carefully consider suggestions. It is important to remember that suggestions are almost always offered constructively, and are not intended to be critical. Answer questions thoroughly and openly, and don’t become defensive. Again, doubts or questions that you can’t answer should be resolved before continuing to the aircraft.

During the pilot’s preflight inspection of the aircraft you may notice or suspect a defect in the aircraft's condition that the pilot may have overlooked. You should wait until the inspection is complete (so you don’t distract the pilot) and then call it to the pilot’s attention.

Other phases of the flight also require that distractions be kept to a minimum. Recent air transport industry statistics show that 67% of airline accidents during a particular survey period happened during only 17% of the flight time -- the taxi, takeoff, climb, approach and landing phases. The FAA has designated these phases of flight as critical, and has ruled that the cockpit environment *must* be free of extraneous activity and distractions during these phases to the maximum extent possible. Regulations that apply only to airlines and commercial operators prohibit crewmembers from performing *any* duties during these phases that are not specifically required for safe operation of the aircraft.

These regulations don't apply to aircraft operated by the CAP, but many pilots have embraced the intent of the regulations and may expect the observer and scanner to act accordingly. Casual conversation should be kept to an absolute minimum during the taxi, takeoff, approach and landing phases. This not only allows for fewer distractions that might interfere with completion of checklists, but will also allow *all* crew members to more clearly hear mission base or air traffic control instructions through the airplane’s radio. The pilot may include, as a part of his briefing, instructions to the other members on this topic. If he does not, the courteous crewmember will inquire concerning the pilot's wishes. Casual conversation during other phases of a flight is permitted (and often encouraged) to the extent that it does not interfere with accomplishing job- and mission-related tasks.

During the taxi, takeoff, transit, approach and landing phases all crewmembers should be looking out for other traffic.

14.2 Crew efficiency

Crew efficiency is determined by factors such as the level of training and experience, the completeness of briefings, how well each crewmember understands their duties, and each person’s ability to anticipate problem areas and other crewmember's needs. We will discuss some factors that improve crew effectiveness.

Let's imagine that you are in the air over the assigned search area. Suddenly, your peripheral vision detects a flash of light coming from the right and toward the rear of the airplane. You direct your head and eyes to the general area. There it is again. It might be coming from a survivor's signal mirror. How do you tell the pilot? First, you use the clock position to establish the clue's direction with regard to the airplane's direction of flight. Then, while keeping your eyes glued to the area of the possible search objective, you call out small directional changes. These directional changes are needed to get close to the clue without turning past it.

14.2.1 The Clock Positions

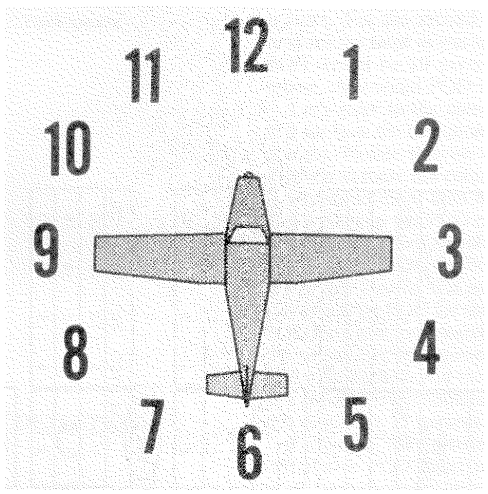


Figure 15-1

This system is used to describe the relative positions of everything outside the airplane. The system considers the clock positions to be on a horizontal plane that is centered within the cockpit. Any object above or below this plane is either "high" or "low."

Imagine yourself in the right rear seat of the airplane. Straight ahead is the twelve o'clock position; straight to the rear is six o'clock. In a real-life situation you probably would be able to see as far ahead as the one o'clock position and as far to the right as five o'clock. (One caution: never divide the clock positions into minutes. There is no such thing as a four-fifteen position.)

If you occupy the left-rear seat of the airplane, your clock positions probably will be seven o'clock through eleven o'clock. In either the right-rear or left-rear seat, the further designation "low" is not used for objects on the ground. They are low, but this is understood.

The clock positions are especially helpful in designating the location of other aircraft within your area of the airspace. Your pilot needs to see all other airplanes in the area so that he can keep clear of them. If you see another airplane, notify the pilot immediately. This time, the high and low designations are appropriate if the other airplane is considerably higher or lower than your altitude. For example, an airplane that is directly ahead but above your altitude should be called out as "aircraft twelve o'clock high."

The "clock position" method of reporting sightings is the standard way crewmembers communicate to each other the relative direction of an observation. It’s easy to learn, and the crewmembers only have to be familiar with the number positions on a clock’s face. Imagine the clock lying face up and the airplane sitting at the center with its nose pointing to the twelve o'clock position, as illustrated in Figure 1-2. You report sightings in the direction the clock's hour hand would be pointing, if pointing at the suspected site. With this method, all reports indicate the same relative direction to other crewmembers.

In spite of this system's relative simplicity, experienced crewmembers still make mistakes during stress or excitement. When reporting an observation to another crew member, one technique that helps keep mistakes to a minimum is to precede the clock position with either "left" or "right" as appropriate. While many people may mistake three and nine o'clock, few mistake left and right. Preceding the clock position with the direction will more likely initially move all eyes in the proper direction. Let's look at some examples.

Also, for this particular situation, remember that you can press a button on the GPS to store the aircraft's present position. By noting that the flash occurred to the right and toward the rear of the airplane, you can recall the stored position and get close to the point where you saw the flash.

14.2.2 Directing the Pilot

Let's say that the flash of light came from the right rear, somewhere near the four o'clock position. You call out "possible at four o'clock." The pilot starts an immediate, medium-bank turn to the right. The pilot knows the four o'clock position but his concept and your concept of this position may not be exactly the same. It looks as if the pilot might swing past your four o'clock. Now what? Don't let it happen! Say something like "straight ahead and level," or "stop turn," or "wings level." The pilot will get the idea.

Getting close to the area of your clue will require small adjustments to direction. Again, tell the pilot what to do. Pilots are accustomed to turning according to numbers of degrees, as shown by the aircraft compass, so you might want to say "five degrees right," or "ten degrees right." The pilot will turn the number of degrees you specify, level off and hold the heading.

If you see what seems to be the search objective, again give the clock position plus other helpful information, such as "near clump of trees." The pilot will bank the airplane and descend to a lower altitude. At this lower altitude identification may be possible. If the clue turns out to be the search objective, mission headquarters will be notified by radio. Your search aircrew will try to remain in the area to direct ground teams to the site. If the clue is not the search objective, your pilot will return to the search track.

When your aircrew team locates a search objective, the scanner's duties change. He no longer needs to scan the ground, so he can keep a sharp lookout for other aircraft. The pilot and observer will be very busy flying the airplane at low level and communicating with other mission units. The preoccupation of the pilot and observer, plus the tendency of other aircraft to congregate at a crash site, leaves the scanners the responsibility for keeping clear of other aircraft.

14.2.3 Task Saturation, Situational Awareness, and Time Management

At times, crews or individual members may be confronted with too much information to manage, or too many tasks to accomplish in the available time. This condition is referred to by many as *task saturation*. This will most likely happen when a crewmember is confronted with a new or different situation, like an emergency, bad weather, or motion sickness. Preoccupation with the different situation may then lead to a condition of "tunnel vision," where the individual can lose track of many other important conditions. In an advanced state, comprehension is so degraded that partial or complete *situational awareness* is lost. When individuals are task saturated to such an extent, communications and the flow of information usually ceases.

The amount of work that any member can handle is directly related to training and experience. Each crewmember must try to keep his or her workload at an acceptable level. If you begin to feel overwhelmed by information or the sheer number of things to do, it's time to evaluate each task, and do only those tasks that are most important. If you ever feel over-tasked, you have an obligation to tell the other crewmembers *before* becoming task-saturated and losing your situational awareness. If others know your performance is suffering, they may assume some of the workload if they can. Once the most important tasks are accomplished and time permits, you can start to take back some of those tasks that were neglected earlier. Allocation of time and establishing priorities is known as *time management*.

Most people can recognize task saturation in themselves and understand how it can affect performance. However, you should also watch for these symptoms in other members of your crew and take over some of their responsibilities if you have the qualifications and can do so without placing your own duties at risk.

The pilot's job is to safely fly the aircraft, and you should be very concerned if she becomes task saturated, or spends an excessive amount of her time with tasks other than flying the airplane. No crewmember should ever allow the work management situation to deteriorate to such an extent as to adversely affect the pilot's ability to safely operate the aircraft. Many accidents have resulted from crews becoming involved in other areas or problems while the airplane literally flew into the ground. If any crew member suspects pilot task saturation to be the case, nonessential discussion should cease, and the crew as a whole should discontinue low-priority aspects of the job, and even return to the mission base if necessary.

14.3 In-flight emergencies

A significant part of each pilot’s training concerns how to handle in-flight emergencies. For the most part, the pilot will handle the problem and should not require a great deal of help from you. However, if the pilot asks you to help, follow his or her directions carefully. Above all, don’t add to the pilot’s concerns by asking too many questions or becoming overly upset. Very few in-flight emergencies are life threatening.

Don’t worry about continuing to scan or maintain the observer log. All crewmembers should be totally committed to helping the pilot safely handle the situation and get the aircraft on the ground. It’s a good idea to cover in-flight emergencies during the preflight briefing and make sure each crewmember knows what to do. The pilot may want you to read the emergency procedure from the checklist or make an emergency radio broadcast so he can focus on the aircraft problem, but that is something that should be agreed on before the flight begins

14.4 Barriers to Communication

Human factors may act as barriers to effective communication between team members, adversely affecting mission performance. Rank, gender, experience level, age, personality, and general attitudes can all cause barriers to communication. You may occasionally be hesitant to offer an idea for fear of looking foolish or inexperienced. You may also be tempted to disregard ideas that come from individuals that have a lower experience level. If you are committed to teamwork and good crew coordination, you must look through such emotions and try to constructively and sensitively adapt to each personality involved.

You can deal best with personalities by continually showing personal and professional respect and courtesy to your teammates. Non-constructive criticism will only serve to build yet another barrier to good communication. Nothing breaks down a team effort faster than hostility and resentment. Always offer opinions or ideas respectfully and constructively. Instead of telling the pilot, "You're wrong," tell him what you *think* is wrong, such as "I think that new frequency was 127.5, not 127.9."

Personal factors, including individual proficiency and stress, may also create barriers to good communication. Skills and knowledge retention decrease over time, and that is why regular training is necessary. If you don't practice regularly, you very likely will spend a disproportionate amount of time on normal tasks, at the expense of communication and other tasks. Civil Air Patrol, the FAA, commercial airlines, and the military services all require certain minimum levels of periodic training for the sole purpose of maintaining proficiency.

Stress can have a very significant, negative effect on cockpit communication. An individual's preoccupation with personal, family, or job-related problems distracts him or her from paying complete attention to mission tasks and communication, depending upon the level and source of stress. The flight itself, personalities of the individuals, distractions, flight conditions, and individual performance can all be sources of communication-limiting stress. When stress reaches very high levels, it becomes an effective barrier to communication and job performance. Many fliers and medical specialists advocate refraining from flying or other complex tasks until the stress is removed.

In an emergency, there will likely be much more stress with which each crewmember must cope. Since very few emergencies result in immediate or rapid loss of an airplane, most experienced aviators recommend making a conscious effort to remain calm, taking the amount of time necessary to properly assess the situation, and only then taking the appropriate corrective action.

Part of your job is also to recognize when others are not communicating and not contributing to the collective decision-making process. Occasionally, other crewmembers may need to be actively brought back into the communication process. This can often be done with a simple "What do you think about that?" In a non-threatening way, this invites the teammate back into the communication circle, and, in most cases, he or she will rejoin the information loop.

Emerging technologies like data-linked freeze frame video (slow scan), digital cameras, and new avionics will challenge the observer to continually expand his skills. Gone are the days where the only mission requirement is a pair of Mark I eyeballs. You are an essential part of the CAP SAR team, and your training and practice will result in the most highly trained observers in CAP history.

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